Series 1960, No. 22
Issued November 1964

Soil Survey
OTTAWA COUNTY
Oklahoma

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Ottawa County, Okla., will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid foresters in managing woodlands; and add to our knowledge of soil science.

Locating the Soils

Use the index to map sheets at the back of this report to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map has been found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they occur on the map. The symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where the symbol belongs.

Finding Information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and Management of the Soils." In this way, they first identify the soils on their farm and then learn how these soils can be managed and what yields can be expected. The "Guide to Mapping Units, Capability Units, and Range Sites" at the back of the report will simplify use of the map and report. This guide lists each soil and land type mapped in the county, and the page where each is described. It also lists, for each soil and land type, the capability unit and range site, and the pages where each of these are described.

Foresters and others interested in woodland can refer to the section "Woodland." In that section the suitability of the soils in the county for trees is discussed and factors affecting the management of woodland are explained.

Engineers and builders will want to refer to the section "Engineering Uses of the Soils." Tables in that section show characteristics of the soils that affect engineering.

Scientists and others who are interested will find information about how the soils were formed and how they were classified in the section "Formation, Classification, and Morphology of Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in Ottawa County will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

* * * * *

Fieldwork for this survey was completed in 1960. Unless otherwise indicated, all statements in the report refer to conditions in the county at that time. The soil survey of Ottawa County was made as part of the technical assistance furnished by the Soil Conservation Service to the Ottawa County Soil Conservation District.

Cover picture: Cattle on Loamy Prairie range site.

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SOIL SURVEY OF OTTAWA COUNTY, OKLAHOMA

BY CLAUDE T. NEWLAND, JOSEPH A. ICENHOWER, AND JOHN B. COX, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION

OTTAWA COUNTY is in the northeast corner of Oklahoma (fig. 1). The total area is 483 square miles, or 309,120 acres. Distance from the southern boundary to the northern is 23 miles, and from the eastern boundary to the western, about 20 miles.

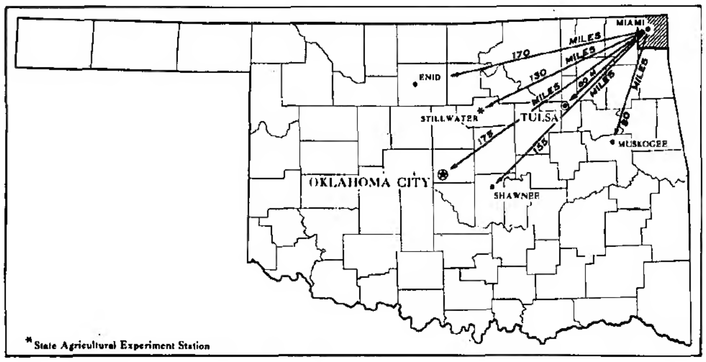

Figure 1.—Location of Ottawa County in Oklahoma.

In 1960, there were 28,301 people in the county, and about half of them lived in Miami, the county seat. Miami is 2 miles north and 2 miles west of the center of the county. Its elevation is 801 feet. The county lies within two physiographic regions.

The western two-thirds of the county is within the Cherokee Prairies. Here the agriculture is based mainly on the raising of livestock and the growing of grain. The soils are used mainly for pasture, grain, and hay crops. The eastern part of the county is part of the Ozark Plateau, and much of the terrain is rugged. In this part of the county, the soils are suited to trees as well as to grass, and farming is more diversified than in the Cherokee Prairies.

How Soils Are Mapped and Classified

Soil scientists made this survey to learn what kinds of soils are in Ottawa County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Bates and Dennis, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural landscape. Soils of one series can differ somewhat in the texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Etowah silt loam and Etowah gravelly silt loam are two soil types in the Etowah series. The differences in texture of their surface layers are apparent from their names.

Some soil types vary so much in slope, degree of erosion number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Bates loam, 3 to 5 percent slopes, is one of several phases of Bates loam, a soil type that ranges from nearly level to moderately sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and

other details that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Newtonia-Sogn complex. Also, on most soil maps areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Alluvial land, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. Based on the yield and practice tables and other data, the soil scientists set up trial groups, and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

After study of the soils in a locality and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations. Such a map is the colored general soil map in the back of this report. Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ in some or in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows, not the kind of soil at any particular place, but patterns of soils, in each of which there are several different kinds of soils.

Each soil association is named for the major soil series in it, but as already noted, soils of other series may also be present. The major soils of one soil association may also be present in other associations, but in a different pattern.

The general map is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Five of the seven soil associations in Ottawa County are in the Cherokee Prairies. The soils there are underlain by sandstone and shale, and the native vegetation was mainly grass. The other two associations are in the Ozark Highlands, in which the bedrock is cherty limestone and the native vegetation included trees.

Soils of the Cherokee Prairies

On the Cherokee Prairies are five soil associations consisting of soils that formed mainly under grasses. The parent material of these soils is dominantly material from sandstone and shale or is alluvium. Some of the soils, however, are from limestone or from calcareous shale.

1. Dennis-Parsons-Bates association

Nearly level to moderately sloping upland soils formed in material from sandstone and shale

This soil association is mostly on broad, nearly level to moderately sloping uplands in the central and western parts of the county. The areas are dissected by V-shaped drainageways. The soils formed under tall prairie grass in material from sandstone and shale of Pennsylvanian age. This association covers about 33 percent of the county.

The Dennis, Parsons, and Bates soils are dominant (fig. 2). The Parsons soils are dominant on the broad flats, and the Dennis and Bates soils are dominant on the slopes.

Dennis soils, the most extensive in the association, are well drained. They have a grayish-brown or dark grayish-brown silty surface layer. Their slowly permeable subsoil is pale-brown, blocky clay loam, silty clay loam, or clay.

The Parsons soils are nearly level to gently sloping. Their permeability is very slow, and in the nearly level areas their drainage is slow. These soils have a grayish-brown or dark grayish-brown silty surface layer, and their subsoil is dark grayish-brown or yellowish-brown, blocky, mottled clay.

Bates soils, less extensive than the Dennis and Parsons, are well drained, moderately permeable soils on gentle or moderate slopes. Their surface layer is grayish-brown or dark grayish-brown loam. Their subsoil is light yellowish-brown or reddish-brown light clay loam or sandy clay loam.

Also in this association are steep Collinsville soils. V-shaped drainageways dissect the area. These drainageways, mapped as Breaks-Alluvial land complex, have steep upland soils on the side slopes and alluvial soils along the narrow bottoms. Other minor soils in the association are the Taloka, Woodson, Verdigris, and Choteau.

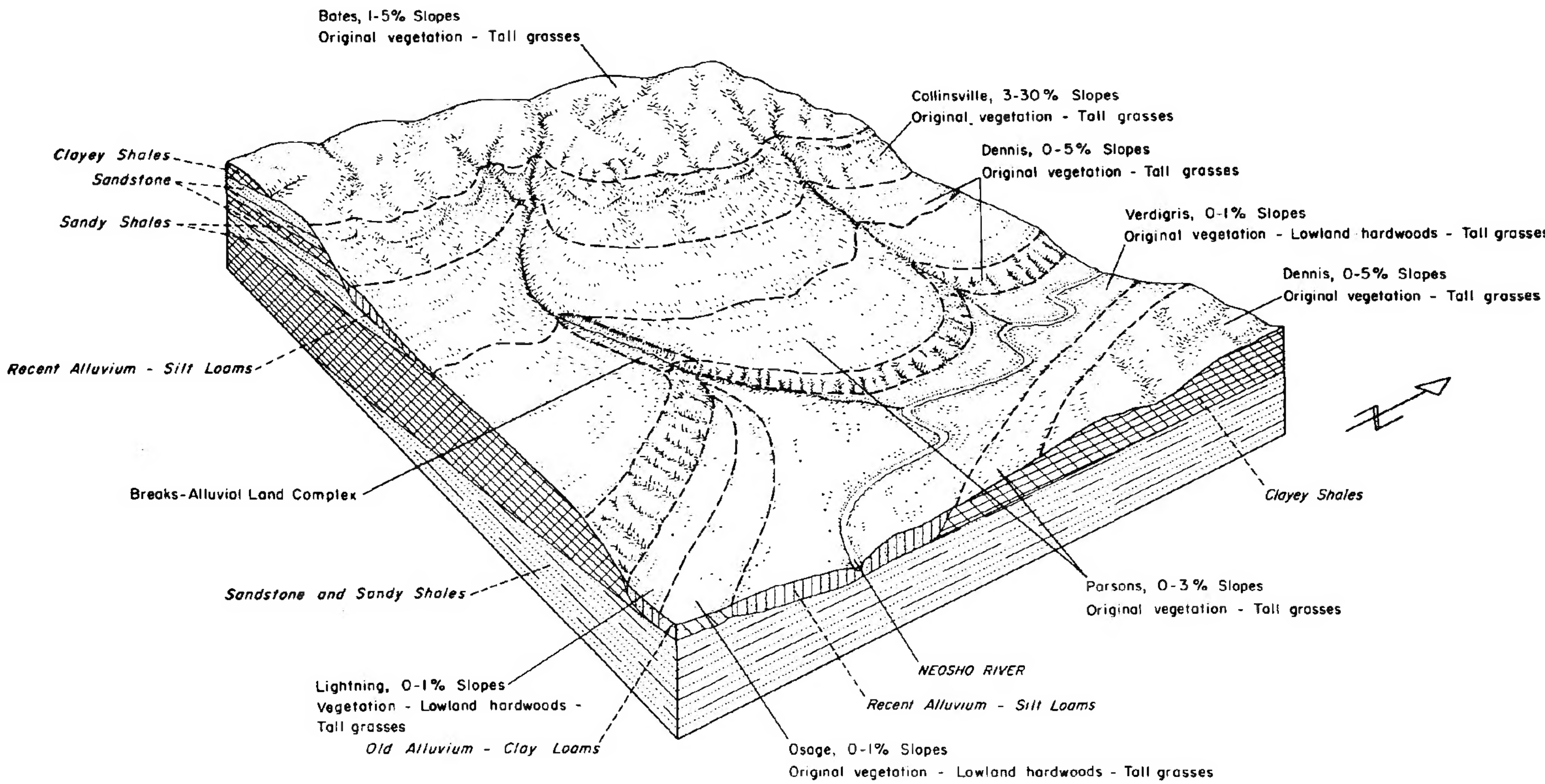

Figure 2.—**Major soil series in soil associations 1 and 3, and their relation to the landscape. Typical slope range is shown for the soil series.**

Much of the acreage in this association is cultivated. The Collinsville soils, however, are too steep and shallow for cultivation. Wheat is the main crop on soils of this association, but corn, sorghum, oats, and soybeans are also grown. Fertility of the soils is fair, but in most places a complete fertilizer is applied to increase yields. Native grasses are of good quality and furnish large amounts of forage and hay.

2. *Dennis-Taloka association*

Nearly level to moderately sloping upland soils formed in material from sandstone and shale or in old alluvium

This soil association is made up of broad, nearly level to moderately sloping uplands cut by V-shaped drainageways. Most of the areas are in the north-central part of the county, but small areas are in the western and southwestern parts. The soils formed under tall prairie grass in material from sandstone and shale or in old alluvium. This association makes up about 16 percent of the county.

Dominant in this association are the Dennis and Taloka soils. Dennis soils formed in material from sandstone and shale and are dominant on the broad flats. Taloka soils formed in old alluvium and are dominant on the slopes.

The Dennis soils are well drained. They have a grayish-brown or dark grayish-brown silty surface layer. Their slowly permeable subsoil is pale-brown, blocky clay loam, silty clay loam, or clay.

Taloka soils are very slowly permeable. Their surface layer is grayish-brown silt loam underlain by a very pale brown layer. The subsoil is grayish-brown or dark grayish-brown, blocky, mottled clay.

Also in this association are Breaks-Alluvial land complex along the sides and bottoms of the V-shaped drainageways. Other minor soils in the association are the Parsons, Bates, Woodson, Verdigris, Lightning, and Choteau.

Much of the acreage in this association is cultivated. Wheat is the main crop, but corn, sorghum, oats, and soybeans are also grown. Fertility of the soils is fair to good. Yields are increased, however, if a complete fertilizer is applied. Lime is needed to correct acidity. Native grasses produce good yields of forage.

3. *Osage-Verdigris-Lightning association*

Nearly level soils on flood plains

This association is made up of acid, nearly level soils on flood plains of the Neosho River and its tributaries. The soils are forming in alluvium washed from soils of the prairies. Tall prairie grass and scattered hardwood trees made up the native vegetation. This association covers about 7 percent of the county.

The Osage, Verdigris, and Lightning soils are dominant in this association (see fig. 2). Osage soils, the most extensive in the association, are somewhat poorly drained and very slowly permeable. They have a very dark gray or black silty clay surface layer. Their subsoil is black or dark-gray clay.

Verdigris soils are generally well drained. These soils have a grayish-brown to very dark grayish-brown silt loam or clay loam surface layer. Their subsoil is pale-brown silt loam or light clay loam and is moderately permeable.

The Lightning soils are somewhat poorly drained. Their surface layer is light brownish-gray or grayish-brown silt loam or clay loam. Below is a thick layer of light-gray, mottled silt loam. The subsoil is coarsely mottled, dark grayish-brown clay loam to silty clay.

Much of the acreage of the Osage and Lightning soils is in tame pasture or native pasture or meadow. If these soils are cultivated, drainage is generally needed. Most areas of Verdigris soils are cultivated, and here corn is the main crop, but wheat and soybeans are also grown. Fertility of the soils is generally high, but lime is needed to correct acidity.

4. *Craig-Eldorado association*

Moderately deep and shallow upland soils formed in material from cherty limestone

This soil association is on gently sloping to strongly sloping uplands. The areas are in the central part of the county near the Lake of the Cherokees and in the northeastern part of the county near the Spring River. The soils formed under tall grass in material from cherty limestone of the Boone formation. About 7 percent of the county is in this association.

Craig soils, the most extensive in the association, are gently sloping to moderately sloping. Their surface layer is grayish-brown or dark-brown silt loam. The moderately permeable subsoil is brown or reddish-brown clay loam and contains chert fragments.

The Craig and Eldorado soils are dominant in this association. The Craig soils are dominant on the smooth areas, and the Eldorado soils are dominant on the breaks and narrow ridges.

The Eldorado soils, which are fairly inextensive, are gently sloping to strongly sloping. These soils have a surface layer of dark grayish-brown or black silt loam. Their subsoil is pale-brown very cherty light clay loam or silty clay loam. On the surface and in the surface layer are stones in various sizes and quantities.

Also in this association are the Dennis and Parsons soils. These soils are acid.

About 60 percent of the acreage of the Craig soils is cultivated. Corn, wheat, oats, sorghum, and soybeans are the main crops. The Craig soils are moderately productive, but in most places a complete fertilizer is applied to increase yields. Eldorado soils are too stony and droughty for cultivated crops and are mostly in grass.

5. *Newtonia-Summit association*

Gently sloping to moderately sloping upland soils formed in material from limestone and shale

This soil association is in a small area on gently sloping or moderately sloping uplands near Fairland. The soils formed under prairie grass in material from calcareous limestone and shale. They are well drained. This association covers only about 1 percent of the county.

Newtonia soils are moderately permeable and are acid. These soils, the most extensive in the association, have a surface layer of brown or reddish-brown silt loam. The subsoil is yellowish-red, granular silty clay loam.

The Summit soils are gently sloping. They have a surface layer of very dark gray, granular silty clay loam. Their slowly permeable subsoil is finely mottled, olive silty clay or clay.

Also in this association are the Sogn soils, which are mapped in a complex with the Newtonia soils. Other minor soils are the Woodson and Dennis soils.

Sogn soils have a thin, very dark gray clay loam surface layer that rests on limestone bedrock. Pieces of limestone are scattered on the surface. Woodson soils are very slowly permeable. They have a black clayey surface layer and a very dark gray, blocky or massive, dense clayey subsoil. Runoff is slow on the Woodson soils.

The moderately productive Newtonia and Summit soils are mostly cultivated. Wheat, oats, corn, soybeans, and grain sorghum are the main crops. The Newtonia-Sogn complex is too stony for cultivation and is in native grass. Much of the acreage of the Woodson soils is cultivated, and wheat, oats, and grain sorghum are the principal crops. Fertility of the Woodson soils is fairly good. These soils, however, have a clayey surface layer, are wet in seasons of high rainfall, droughty during dry spells, and difficult to cultivate.

Soils of the Ozark Highlands

On the Ozark Highlands are two soil associations consisting of soils that formed mainly under hardwoods. The parent material of these soils is cherty limestone or alluvium.

6. *Bodine-Baxter association*

Nearly level to steep upland soils formed in material from cherty limestone

This soil association consists of nearly level to steep and rocky areas on uplands adjacent to and east of the Spring River. The soils formed in material from cherty limestone of the Boone formation of Mississippian age. Oak, hickory, and other hardwood trees made up the native vegetation. This association makes up about 29 percent of the county.

The Bodine and Baxter soils are dominant (fig. 3). The stony Bodine soils are dominant on the steep and rocky breaks, and the other Bodine soils and the Baxter soils are dominant on the smooth ridgetops.

Bodine soils, the most extensive in the association, are rapidly permeable and cannot hold enough moisture to carry plants through dry spells. They have a thin, grayish-brown or black, organic-mineral surface layer of cherty silt loam or stony silt loam. Below is a thick layer of pale-brown very cherty silt loam. The subsoil is mostly chert, but light yellowish-brown, brown, or red silty clay loam or clay loam is in the crevices.

The Baxter soils have a thin surface layer of grayish-brown or brown silt loam underlain by a thick, pale-brown layer. The subsoil is yellowish-red or red silty clay loam or silty clay and contains varying amounts of chert. Baxter soils are very cherty in the subsoil or below the subsoil.

Also in this association are the nearly level, slowly permeable Lawrence soils on ridgetops. These soils have a thin, silty surface layer that is underlain by a thick, very pale brown silty layer. Their subsoil is yellowish-brown to grayish-brown, blocky, mottled silty clay loam.

Cleared areas in this association are used mainly for tame pasture crops, but some corn, wheat, oats, and grain sorghum are grown. Most areas of the Bodine soils are in woods used for grazing. The Baxter and Lawrence soils are mostly cultivated. Fertility of the soils in this association is low to moderate. The supply of organic matter is low and difficult to maintain.

7. *Huntington-Etowah association*

Nearly level to moderately sloping gravelly soils formed in alluvium on flood plains and benches

In this association are nearly level to moderately sloping soils on flood plains and benches in valleys of the Spring River and its tributaries. The soils formed in alluvium washed from cherty soils on uplands. They are well drained and medium acid to strongly acid. About 7 percent of the county is in this association.

Dominant in this association are the Huntington soils, which formed in recent alluvium, and the Etowah soils, which formed in old alluvium (see fig. 3).

The Huntington soils are on the nearly level flood plains, and the Etowah soils are on the nearly level to moderately sloping benches.

Huntington soils are the most extensive in the association. They have a surface layer of grayish-brown or dark grayish-brown silt loam or gravelly silt loam. Their subsoil is brown to very dark grayish-brown gravelly or very gravelly silt loam or silty clay loam. The silt loam is mostly in broad areas along the larger streams, and the gravelly silt loam is along the smaller streams.

The Etowah soils have a grayish-brown or dark-brown silty or gravelly surface layer. Their subsoil is yellowish-red or reddish-yellow clay loam. The gravel in the subsoil ranges from none in the upper part to 50 percent of the volume in the lower part.

Much of the acreage in this association is cultivated. Corn is the main crop in most large areas, but tame pasture crops are grown in most small areas. The soils are moderately productive. Yields are increased if a complete fertilizer is applied.

Use and Management of the Soils

This section first describes the general practices of management used for cultivated soils. Then the system of capability grouping is explained, and the use and management of the soils in each capability unit are discussed. Following this are estimated average yields of principal crops and use and management of the soils for range, for woodland, and for wildlife. Last discussed are the uses of the soils for engineering.

General Management Practices [1]

The main problems of management in growing tilled crops in Ottawa County are controlling erosion, maintaining good tilth, supplying sufficient amounts of plant nutrients to maintain productivity, and removing excess water. Necessary management practices are using suitable cropping systems, using proper tillage, growing cover crops, using crop residues, applying fertilizer, constructing terraces, grassing waterways, improving drainage, and growing tame pasture crops.

Generally, a combination of practices is needed to improve the soils and protect them against erosion. Many of the practices needed, however, are common to all the

[1] By E. O. HILL, conservation agronomist, Soil Conservation Service.

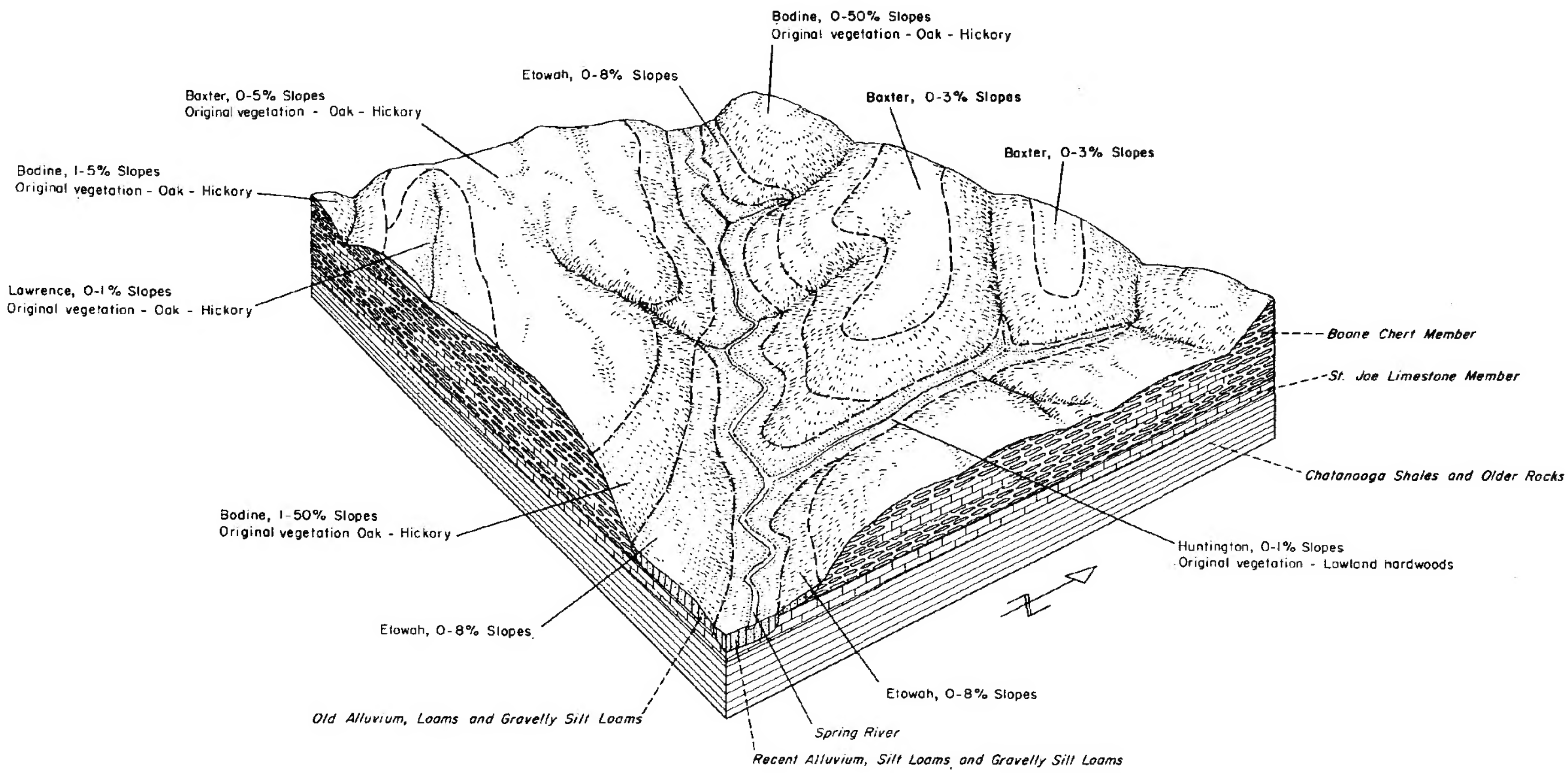

Figure 3.—**Major soil series in soil associations 6 and 7, and their relation to the landscape. Typical slope range is shown for the soil series.**

soils. These general practices are discussed in the paragraphs that follow. Their specific application to the capability units is discussed in the subsection "Management by Capability Units."

Cropping systems.—A good cropping system maintains the soils in good tilth and assures good yields of crops at the most economic cost. Such a cropping system also protects the soils from erosion and helps in controlling weeds, insects, and diseases. Legumes and grasses, or other high residue producing crops, are needed in the cropping system (fig. 4). If nonleguminous, high residue producing crops are grown, nitrogen fertilizer should be applied to hasten decomposition of the residues and prevent a nitrogen deficiency to the succeeding crop.

Figure 4.—**Plowing under a crop of sweetclover grown in the cropping system to improve the soil and protect it from erosion; sweetclover also provides supplemental pasture and food and cover for wildlife.**

The main field crops grown in Ottawa County are corn, soybeans, grain sorghum, and wheat and other small grains. A large acreage is in grasses and legumes used for tame pasture; these plants are excellent soil-improving crops when grown in a long cropping system.

Tillage.—It is necessary to use minimum tillage at the proper time on all cultivated soils in this county. When the soils are used for crops, they must, of course, be worked to prepare a seedbed, to control weeds, and to provide a favorable place for plants to grow. However, excessive tillage or tillage done when the soils are too wet breaks down soil structure and causes the soils to puddle and crust at the surface. As a result, the soils take in less water and air and store less moisture for plants.

Compaction is a problem in managing the soils in this county. If the soils are cultivated year after year to the same depth, a dense, compact layer, or plowpan, forms, particularly in soils that are medium or heavy in texture. This pan, just below plow depth, reduces aeration and the intake of moisture. It also restricts the normal growth of roots.

Use of cover crops.—Cover crops are grown on many of the soils in this county to protect them from erosion during winter and early in spring when they would otherwise be unprotected. The practical experience of farmers in the county shows that the benefits from a cover crop more than offset the cost of establishing it. Growing a small grain or vetch as a cover crop generally increases the yields of other crops grown in the cropping sequence.

Using crop residues.—Leaving crop residues on the surface during periods when erosion is critical or working them partly into the surface soil are desirable practices on all of the soils. Crop residues contain a part of the nutrients the plants took from the soil when they were growing. When these residues are returned to the soil, they restore some of the nutrients that were removed by the crop. Furthermore, they improve the tilth of the surface layer and reduce surface crusting. Consequently, infiltration of water is increased and the storage of moisture improved.

Use of fertilizer.—Most of the soils in this county need applications of a complete fertilizer for good yields. The annual rainfall is between 40 and 45 inches. If a complete fertilizer is applied, crops grown on the soils respond well during years when rainfall is normal. The fertilizer should be applied in the amounts indicated by soil tests and the needs of the crop to be grown. Most of the soils in the county need lime, especially if a crop that requires a large amount of lime is to be grown.

Use of terraces.—A terrace is a combination of a ridge and channel built across the slope to divert or slow the flow of water. Terraces reduce erosion and help to conserve water. They also help to remove excess water and serve as guidelines for contour farming.

If sloping soils are terraced, yields can be maintained on them. But, if such soils are not terraced, they erode and yields gradually decline.

Grassed waterways.—When water that collects behind terraces cannot be spilled on well sodded pastures or meadows, grassed waterways are needed. Natural drainageways, where water also collects, should be grassed. Grassed waterways generally are broad, grass-covered, flat-bottomed channels. They have a retaining dike on each side if needed. Bermudagrass is the principal grass used in waterways.

Drainage.—Many of the soils in this county are fairly flat and require drainage to remove excess surface water. Crops make some yields on most of the slightly wet soils of the county, but yields are increased if surface drainage is provided. Some of the soils are too wet for crops in wet seasons; these soils can be made moderately productive if drainage is provided.

Drainage can be accomplished by ditching, land leveling, and directing the rows to suitable outlets. Professional help is needed in designing and constructing a drainage system and can be obtained from the representatives of the Soil Conservation Service.

Tame pastures.—Many cultivated areas in Ottawa County are best suited to tame pasture plants because of steep slopes and shallowness of the soil over bedrock. Some cultivated areas have a cover of brush and weeds, but on some farms and ranches the brush and weeds have been removed and good tame pastures established. Some soils well suited to cultivation are also used for tame pasture.

A well-planned pasture program provides economical feed for livestock in winter and summer (fig. 5). In addition, the plants help to protect the soil and to keep it in good tilth. In planning a pasture program it is necessary to consider the needs of the soil and its suitability for pasture, the season when additional forage is needed for the livestock, the most suitable grass, and the best kind of legumes to grow with the grass.

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Figure 5.—One of many well-managed tame pastures in Ottawa County.

Perennial grass is used as a foundation for all tame permanent pastures, but a mixture of legumes and grass is preferred. The mixture should consist of 60 to 80 percent of grass to provide good forage. Bermudagrass, annual lespedeza, and sericea lespedeza are the plants generally used for summer pastures. Tall fescue, ladino clover, and yellow hop clover are generally used for winter pastures. If grazing is regulated and brush and weeds are controlled, yields are increased and pasture plants last longer

Fertilizer is needed for high yields. Generally, large amounts of nitrogen and phosphate are needed, but the requirements for phosphate and lime vary, depending on the kind of soil and plants grown.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soils are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no susceptibility to erosion but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows:

Class I. Soils that have few limitations that restrict their use.
- (No subclasses.)
  - Unit I-1. Deep, nearly level, silty or clayey soils on bottom lands.
  - Unit I-2. Deep, nearly level, silty soils on uplands.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe-1. Deep, dark-colored, gently sloping, slowly permeable soils on upland prairies.
  - Unit IIe-2. Deep or moderately deep, moderately or slowly permeable soils on uplands.
- Subclass IIw. Soils that have moderate limitations because of excess water.
  - Unit IIw-1. Deep, well-drained, nearly level, gravelly soils on flood plains.
- Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.
  - Unit IIs-1. Deep, nearly level soils that have a claypan subsoil and are very slowly permeable.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe-1. Deep, or moderately deep, gently sloping or moderately sloping soils that have moderate or slow permeability and are on uplands.
  - Unit IIIe-2. Deep, gently sloping, silty and clayey soils that have a claypan subsoil and are on uplands.
  - Unit IIIe-3. Deep or moderately deep, moderately eroded soils on uplands.

Subclass IIIw. Soils that have severe limitations because of excess water.

Unit IIIw–1. Deep, nearly level, silty and clayey soils on bottom lands that are flooded occasionally.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe–1. Deep, gently sloping, silty and and eroded soils that have a claypan subsoil.

Unit IVe–2. Deep, moderately sloping to strongly sloping soils that have a gravelly subsoil and are on terraces.

Unit IVe–3. Gently sloping to moderately sloping, loamy, upland soils that have a thin subsoil and are shallow over sandstone.

Subclass IVs. Soils that have very serious limitations of stoniness, low moisture capacity, or other soil features.

Unit IVs–1. Deep, very cherty upland soils that have a very cherty, rapidly permeable subsoil.

Class V. Soils not likely to erode that have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.

Unit Vw–1. Land that is adjacent to stream channels and is flooded frequently.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion, if protective cover is not maintained.

Unit VIe–1. Soils on uplands and alluvial land on bottoms.

Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Unit VIs–1. Shallow or very shallow, gently sloping to strongly sloping, stony soils.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing, woodland, or wildlife food and cover.

Subclass VIIs. Soils very seriously limited by moisture capacity, stones, or other soil features.

Unit VIIs–1. Deep, stony, steep soils that have rapid permeability.

Unit VIIs–2. Very shallow, moderately steep to steep, loamy soils.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIs. Rock or soil materials that have little potential for production of vegetation.

Unit VIIIs–1. Piles of rock and chat from mines.

Management by Capability Units

In this section each capability unit in Ottawa County is described and the soils in each are listed. Suggestions are given on how to use and manage the soils in each unit.

Capability unit I–1

This unit consists of deep, nearly level, silty or clayey soils on bottom lands. These soils are generally well drained and have slow to moderately rapid permeability. They are slightly acid or medium acid. Supplies of organic matter and plant nutrients are moderate to high. The soils in this unit are –

Huntington silt loam.
Kaw silty clay loam.
Verdigris silt loam.

Corn, small grain, soybeans, and grain sorghum are the main crops. Alfalfa can be grown if lime and a fertilizer that contains phosphate are applied.

Bermudagrass or fescue, overseeded with yellow hop clover, annual lespedeza, and hairy vetch, are the main plants grown in tame pastures. Yields are good. Catalpa and black locust trees are grown successfully for posts.

The principal problems in managing these soils are maintaining soil structure and the supply of plant nutrients. Row crops can be grown year after year and good yields maintained if a grass or a legume crop, or a winter cover crop, is turned under every fifth year. Wheat, corn, and other crops that produce large amounts of residues can be grown year after year if the residues are returned to the soils and nitrogen fertilizer is applied to hasten decomposition of the residues. Lime and a complete fertilizer should be applied in the amounts indicated by soil tests and according to the requirements of the crop to be grown.

Capability unit I–2

This unit consists of deep, nearly level, silty soils on uplands. These soils are well drained and have moderate to slow permeability. They are strongly acid. Supplies of organic matter and plant nutrients are good. The soils in this unit are—

Choteau silt loam, 0 to 1 percent slopes.
Dennis silt loam, 0 to 1 percent slopes.

These soils are well suited to all crops generally grown in the county. Corn, small grain, soybeans, and grain sorghum are the main crops. Alfalfa can be grown if lime and a fertilizer that contains phosphate are applied. Tame pasture crops produce good yields on these soils.

The principal problems in managing these soils are maintaining soil structure and the supply of plant nutrients. If row crops are grown, a grass or a legume crop is needed in the cropping system at least one-fourth of the time. Wheat or oats can be grown year after year if the residues are returned to the soils and a fertilizer that contains nitrogen is applied. Fertilizer and lime should be applied in the amounts indicated by soil tests and according to the requirements of the crop to be grown.

Capability unit IIe–1

Summit silty clay loam, 1 to 3 percent slopes, is the only soil in this unit. It is a deep, dark-colored, gently sloping soil on upland prairies. This soil is well drained, but it has slow permeability. The surface layer is slightly

acid, and the subsoil is neutral or mildly alkaline. Supplies of organic matter and plant nutrients are high.

All crops commonly grown in the county can be grown on this soil, but small grain, corn, soybeans, and grain sorghum are the main crops.

Erosion is the principal problem in managing this soil. Other problems are maintaining soil structure and the supply of plant nutrients.

Using terraces with protected outlets, farming on the contour, returning crop residues to the soil, and sowing crops or drilling them in will help to reduce runoff and control erosion. Growing a grass, a legume, or a cover crop at least one-fourth of the time helps to maintain organic matter and soil structure. If row crops are grown and terraces are not used, a grass or a legume should be grown at least one-third of the time to control erosion. Apply fertilizer in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IIe-2

In this unit are deep or moderately deep, moderately or slowly permeable soils on uplands. These soils are nearly level or gently sloping and are well drained. Their surface layer is loam or silt loam. The subsoil ranges from sandy clay to clay. These soils are acid. Most of them have a good supply of organic matter. Fertility is fair to good. The soils in this unit are—

Bates loam, 1 to 3 percent slopes.
Baxter silt loam, 1 to 3 percent slopes.
Choteau silt loam, 1 to 3 percent slopes.
Craig silt loam, 1 to 3 percent slopes.
Dennis silt loam, 1 to 3 percent slopes.
Etowah silt loam, 0 to 3 percent slopes.
Newtonia silt loam, 1 to 3 percent slopes.

These soils are well suited to all crops generally grown in the county, but small grain, corn, soybeans, and grain sorghum are the chief crops. Alfalfa can be grown on all but the Baxter and Craig soils if lime and a fertilizer that contains phosphate are applied. The Baxter and Etowah soils are suited to hardwood and pine trees and to trees grown for posts. All of the tame pasture plants commonly grown produce good yields on all of the soils.

Erosion is a problem in managing these soils. Other problems are maintaining soil structure and the supply of plant nutrients. The following practices help to control erosion: (1) Using terraces with protected outlets, particularly if row crops are grown; (2) farming on the contour; (3) growing high-residue crops; (4) returning crop residues to the soils; and (5) growing a grass or a legume crop at least one-fourth of the time.

If this soil is cultivated and terraces are not used, a grass or a legume crop is needed at least one-third of the time for control of erosion. The grass or legume also helps to maintain organic matter, to build up soil structure, and to reduce runoff. Lime and fertilizer should be applied in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IIw-1

Huntington gravelly silt loam is the only soil in this unit. It is a deep, nearly level soil on flood plains. This soil is well drained and has moderate permeability. The surface layer is gravelly silt loam, but the subsoil is gravelly silty clay loam. The supplies of organic matter and plant nutrients are medium.

This soil is flooded occasionally in places, and as a result, the choice of crops that can be grown is restricted. Other than flooding, the principal problems in managing these soils are maintaining soil structure and the supplies of plant nutrients.

This soil is used mainly for tame pasture crops, and yields are good. However, corn, small grain, and grain sorghum are also grown. Hardwood trees grow well on this soil. Trees also can be grown successfully for posts.

If row crops are grown on this soil, a grass or a legume crop should be grown and turned under about every fourth year. Wheat, oats, or other high-residue crops are needed in the cropping system. The crop residues should be protected from grazing and returned to the soil. Apply lime and fertilizer in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IIs-1

This unit consists of deep, nearly level soils that have a claypan subsoil and are very slowly permeable. These upland soils have a silty or clayey surface layer over a clayey subsoil. They are strongly acid to very strongly acid. Supplies of organic matter and plant nutrients are low in the Lawrence soils but moderate to high in the other soils. These soils are droughty. They take in and store large quantities of water but release it slowly to plants. The soils in this unit are—

Lawrence silt loam.
Parsons silt loam, 0 to 1 percent slopes.
Taloka silt loam, 0 to 1 percent slopes.
Woodson silty clay loam, 0 to 1 percent slopes.

These soils are better suited to crops that mature early than to crops that mature later in the season when little moisture is available. The chief crops are small grain, grain sorghum, and tame pasture plants.

The principal problems in managing these soils are droughtiness and maintaining soil structure and the supply of plant nutrients. Except on long slopes, the hazard of erosion is not serious.

On long slopes and where runoff concentrates, terraces are needed to divert the water and keep it from accumulating. Where terraces are used, farming should be on the contour. If grain crops are grown, a grass or a legume is needed in the cropping system at least one-fourth of the time. Sweetclover, sericea lespedeza, and other deep-rooted legumes help to increase the intake of water and to maintain soil structure. Lime and fertilizer should be applied in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IIIe-1

This unit consists of deep or moderately deep, gently sloping or moderately sloping soils that are moderately or slowly permeable. These upland soils are well drained and are acid. Their supplies of organic matter and plant nutrients vary. The soils have fair to good moisture-storage capacity, but much rainfall is lost through runoff. The soils in this unit are—

Bates loam, 3 to 5 percent slopes.
Baxter silt loam, 3 to 5 percent slopes.
Craig silt loam, 3 to 5 percent slopes.
Dennis silt loam, 3 to 5 percent slopes.
Newtonia silt loam, 3 to 5 percent slopes.
Riverton gravelly loam, 3 to 5 percent slopes.

Corn, small grain, soybeans, and grain sorghum are the main crops grown on these soils.

Erosion, caused by the large amount of runoff, is the principal management problem. Other problems are maintaining the supply of plant nutrients and the structure of the soils.

The following practices help control erosion: (1) Using terraces with protected outlets, (2) choosing suitable cropping systems, (3) farming on the contour, (4) returning crop residues to the soils, and (5) growing a grass or legume crop at least one-third of the time. Lime and fertilizer should be applied in amounts indicated by soil tests and according to the needs of the crop.

If row crops are grown and terraces are not used, erosion cannot be controlled. If drilled crops are grown and terraces are not used, a grass or legume crop is needed at least one-half of the time for control of erosion.

Tame pastures consist mainly of bermudagrass overseeded with yellow hop clover and annual lespedeza. Yields are good.

Capability unit IIIe-2

In this unit are deep, gently sloping, silty and clayey soils that have a claypan subsoil and are on uplands. These soils have very slow permeability. Their supplies of organic matter and plant nutrients are low to medium. The Parsons soil is acid, but the Woodson is neutral. The soils in this unit are -

Parsons silt loam, 1 to 3 percent slopes.
Woodson silty clay loam, 1 to 3 percent slopes.

The soils in this unit are suited to cultivation, but small grains and other crops that mature early produce better yields than crops that mature later in the season when little moisture is available.

Erosion, caused by the large amount of runoff resulting from the slope and very slow permeability, is the principal management problem. Other problems are maintaining soil structure and the supply of plant nutrients.

Intensive practices are needed for the control of erosion, and among them are the following: (1) Using terraces with protected outlets, particularly if row crops are grown; (2) farming on the contour; (3) growing a grass or a legume in the cropping system at least one-third of the time; and (4) returning crop residues to the soils. Deep-rooted legumes help to increase the intake of water and to improve tilth. Lime and fertilizer should be applied in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IIIe-3

This unit consists of deep or moderately deep, moderately eroded soils on uplands. These soils are acid. Because they are eroded, these soils are low in organic matter and plant nutrients. They have a thinner surface layer and are therefore more susceptible to further erosion than similar soils that are not eroded. These soils have good moisture-holding capacity, but they have slow or moderate permeability. The soils in this unit are—

Bates loam, 2 to 5 percent slopes, eroded.
Dennis silt loam, 2 to 5 percent slopes, eroded.
Newtonia silt loam, 2 to 5 percent slopes, eroded.

The main crops grown on these soils are small grain, grain sorghum, and tame pasture plants. Low supplies of organic matter and plant nutrients and a thin surface layer make the soils poorly suited to corn and soybeans.

Erosion and the maintaining of soil structure and the supply of plant nutrients are the principal problems in managing these soils. If these soils are cultivated, terracing and farming on the contour are needed. Grasses, legumes, or other high-residue crops, such as wheat or oats, are needed in the cropping system at least one-half of the time. If nonlegumes are grown, return all of the residues to the soil and add nitrogen to hasten their decomposition. Apply lime and fertilizer in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Tame pasture crops can be grown successfully on these soils if fertilizer is applied. Tame pastures consist mainly of bermudagrass overseeded with annual lespedeza and yellow hop clover.

Capability unit IIIw-1

This unit consists of deep, nearly level, silty or clayey soils on bottom lands. These soils are somewhat poorly drained and have very slow permeability. They are flooded about once a year and are wet in places. The wetness causes difficulty in tillage and restricts the choice of crops. The soils in this unit are—

Lightning silt loam.
Osage silty clay.

The soils in this unit are better suited to grass or trees than to cultivated crops. Nevertheless, some areas that are not too wet are used for corn, small grain, grain sorghum, and tame pasture plants. Fescue also grows well where the soil is not too wet, and it provides grazing in fall and spring.

Wetness is the chief hazard on these soils. In dry seasons, however, the surface layer crusts and the soils are droughty. As a result, maintaining soil structure is difficult.

If these soils are cultivated, drainage is needed. Growing a grass or a legume in the cropping system at least one-half of the time helps to maintain organic matter and soil structure and increases the intake of water.

Lime and fertilizer should be applied in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Assistance in designing and establishing a drainage system can be obtained through the local Soil Conservation District office.

Capability unit IVe-1

Parsons silt loam, 1 to 3 percent slopes, eroded, is the only soil in this unit. It is a deep, gently sloping, silty soil that has a claypan subsoil. Because this soil is moderately eroded, the supplies of organic matter and plant nutrients are somewhat depleted.

This soil is better suited to grass than to cultivated crops. It can be cultivated occasionally, however, if it is managed carefully. Bermudagrass overseeded with yellow hop clover and annual lespedeza produces fair yields of forage.

Erosion is the most serious hazard, but this soil is also droughty. If this soil is cultivated, terraces with protected outlets are needed and farming should be on the contour. A cropping system that supplies organic matter is also needed. A suitable cropping system is

3 or 4 years of sericea lespedeza or fescue, followed by 1 year of wheat or oats. Apply lime and fertilizer in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IVe-2

Etowah gravelly silt loam, 3 to 8 percent slopes, is the only soil in this unit. It is a deep, moderately sloping to strongly sloping soil that has a gravelly subsoil and is on terraces. This soil is well drained. It is strongly acid to very strongly acid. Supplies of organic matter and plant nutrients are medium.

This soil is best suited to grass or trees, but it can be cultivated occasionally if it is managed carefully. Bermudagrass overseeded with yellow hop clover and annual lespedeza produces good yields if properly managed, and so do other tame pasture plants. Pine and hardwood trees are well suited, and trees can be grown successfully for posts.

If this soil is cultivated, a cropping system that will add organic matter is needed. A suitable cropping system is 3 or 4 years of bermudagrass, followed by 1 year of oats. Adding lime and fertilizer in the amounts indicated by soil tests and according to the needs of the crop helps to increase yields.

Capability unit IVe-3

Bates loam, shallow, is the only soil in this unit. It is a gently sloping to moderately sloping upland soil that is shallow over sandstone. Depth to the sandstone ranges from 12 to 20 inches.

This soil is well drained and has moderate permeability. It is slightly acid to medium acid. The content of organic matter is moderate. This soil has a lower supply of plant nutrients than the other Bates soils, since it has less depth for storage of plant nutrients.

This soil is susceptible to erosion. It lacks capacity for storage of large quantities of moisture and is droughty. Maintaining soil structure and the supply of plant nutrients are problems in managing this soil.

This soil is better suited to grass than to cultivated crops. If bermudagrass is established, however, oats or wheat can be grown occasionally. A cover should be kept on this soil as much of the time as feasible. If this soil is cultivated, terracing and farming on the contour are needed. Apply lime and fertilizer in the amounts indicated by soil tests and according to the needs of the crop to be grown.

Capability unit IVs-1

In this unit are deep, very cherty upland soils that have a very cherty, rapidly permeable subsoil. These soils are gently sloping to strongly sloping. Supplies of organic matter and plant nutrients are low. The soils in this unit are—

- Bodine cherty silt loam, 0 to 3 percent slopes.
- Bodine very cherty silt loam, 1 to 8 percent slopes.

The soils in this unit are droughty. They take in large quantities of water, but they have little moisture-storage capacity and leach severely. Because of the rapid permeability and the content of chert, erosion is not serious on these soils.

These soils are better suited to grass or trees than to cultivated crops. A cultivated crop can be grown occasionally if necessary, but large amounts of organic matter and fertilizer are needed for good yields. Pines and hardwoods grow well on these soils.

Capability unit Vw-1

Alluvial land, a miscellaneous land type, is in this unit. It consists of areas that are adjacent to stream channels and that are flooded several times each year. The areas occur throughout the county and are made up mainly of soils of the Huntington, Osage, and Verdigris series. Most of this land is covered with native trees and grass.

This land type is generally used for pasture. It is fairly productive; but it is flooded frequently, and economical production of cultivated crops is not possible.

In cleared areas tame pasture crops are grown in many places. Here the pasture plants that are best suited are bermudagrass or fescue overseeded with yellow hop clover and annual lespedeza. If tame pasture crops are grown, weeds must be controlled and proper stocking used. Adding lime and fertilizer increases yields.

Capability unit VIe-1

Breaks-Alluvial land complex is in this unit. It consists of steep soils on uplands and of alluvial areas on bottom lands. The areas occur throughout the uplands on the prairies in V-shaped, entrenched drainageways.

Large amounts of runoff from surrounding areas concentrate on areas of this complex and cause severe erosion. This complex is, therefore, not suited to cultivation and is best used for grass.

Except for a few small areas, all of this unit is in native grass used for grazing or hay. On areas that have been cultivated, perennial vegetation can be reestablished by planting bluestem, bermudagrass, or similar grasses. Overseeding the bermudagrass with suitable legumes increases yields and also increases the length of the grazing season. Yields are also increased if lime and fertilizer are added and weeds are controlled.

Capability unit VIs-1

This unit consists of shallow or very shallow, gently sloping to strongly sloping, stony soils. Between the stones are pockets of deep, loamy soils. These soils formed under prairie grass and are droughty. Soils in this unit are—

- Eldorado soils.
- Newtonia-Sogn complex.

These soils are not suited to cultivation. They are suited only to grass, and most areas are in native grass used for pasture or hay. Only a few small areas have been cultivated. Bermudagrass is grown in a few small areas, generally those that adjoin deeper soils. Yields are increased if fertilizer is applied. Control of grazing helps to maintain a good cover of grass, to control erosion, and to improve yields.

Capability unit VIIs-1

Bodine stony silt loam, steep, is the only soil in this unit. It is deep and stony and has rapid permeability. The subsoil is very cherty. Supplies of organic matter and plant nutrients are low. The soil takes in large quantities of water, but it has little moisture-storage capacity and leaches severely.

Most areas of this soil are wooded and are used for grazing. Because of steep slopes, stones, low fertility, and droughtiness, the soil is not suited to cultivation. It is, therefore, best suited to grass or to pine and hardwood trees.

If this soil is used for grass, practices are needed to prevent sprouts and brush from encroaching. If grazing is controlled, fair yields of forage can be produced on areas that have a cover of trees and grass.

Capability unit VIIs-2

Collinsville soils is the only mapping unit in this capability unit. These are very shallow, moderately steep to steep, loamy soils of the uplands. Their surface layer is 2 to 15 inches thick and rests on sandstone. Pieces of sandstone are on the surface in many places. There is little depth for the storage of moisture.

These soils are not suited to cultivation, and they are best used for native grasses. Most of the areas are used for pasture or hay. Grazing must be controlled if high yields are to be obtained and erosion prevented.

Capability Unit VIIIs-1

Mine pits and dumps, a miscellaneous land type, is in this capability unit. It consists of piles of rock and chat from zinc and lead mines.

This land type is not suited to cultivated crops, grass, or trees. The areas have value mainly for wildlife and as scenic areas for tourists.

Estimated Yields [2]

Estimated average yields per acre of the principal crops grown in Ottawa County under two levels of management are shown in table 1. The yield figures given are estimated long-time averages. Crop failures have been included in the averages.

The estimates are based on interviews with farmers; on results of research applicable to the soils of the county, and on observations made by soil surveyors, work unit conservationists, and other agricultural workers who are familiar with the soils.

The yields in columns A are those obtained under common management, or the management generally used by most farmers in the county. Common management practices are (1) using recommended varieties of adapted crops; (2) using proper rates of seeding, proper dates of planting, and efficient methods of harvesting; (3) controlling weeds, insects, and diseases sufficiently to insure the growth of plants; and (4) applying a minimum amount of fertilizer.

The yields in columns B are those obtained under improved management. Generally, improved management includes the practices used under common management and the following: (1) Choosing suitable cropping systems; (2) applying fertilizer in the amounts indicated by soil tests; (3) returning crop residues to the soils; (4) using tillage methods that help to control erosion, improve soil structure, increase infiltration of water, and encourage emergence of seedlings; (5) farming on the contour; (6) terracing and use of grassed waterways where necessary; and (7) improving drainage where needed. These practices are discussed in the subsection "General Management Practices."

[2] By RUEL BAIN, soil scientist, Oklahoma State University.

Not all of the practices listed under common or improved management are necessarily needed in managing the soils on a particular ranch or farm. On some soils, for example, only a few of the practices listed under improved management may be needed to get maximum economic yields.

Range Management [3]

In Ottawa County, according to an inventory of conservation needs, land in native grasses used for pasture amounted to 70,200 acres, or about 24 percent of the land in farms and ranches. Livestock operations are largely production of beef and dairy cattle. The number of cattle and calves in the county has ranged from about 24,000 in 1950 to more than 28,000 in 1959.

Rangeland used as pasture consists principally of native grasses, forbs, and shrubs that are valuable for forage and sufficient in quantity to justify use of the areas for grazing. Generally, the deep and nearly level soils in the county were plowed and used for crops, and the rough, steep, or rocky areas were left in native pasture.

Much of the rangeland in Ottawa County is now producing below its potential. These areas can be improved for forage if well managed. Well-managed prairie pastures and meadows have a mixture of tall grasses composed principally of big bluestem, little bluestem, switchgrass, Indiangrass, and numerous native perennial legumes and other forbs. Such plants can be maintained if proper grazing is used and other good management practices are applied.

In this section a discussion of range sites and condition classes is given. Then the individual range sites are described and the soils in each are listed. Following this, estimated yields of forage are given and principles of range management that apply to all the range sites are discussed.

Range sites and condition classes

Different kinds of soil vary in their capacity to produce grass and other plants for grazing. The soils that will produce about the same kind and amount of forage if the ranges are in similar condition make up what is called a range site.

Range sites are kinds of rangeland that differ from each other in their ability to produce vegetation. The soils of any one range site produce about the same kind of climax vegetation. *Climax vegetation* is the stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment remains unchanged. Throughout most of the prairie and the plains, the climax vegetation consists of the plants that were growing there when the region was first settled. If cultivated crops are not to be grown, the most productive combination of the forage plants on a range site is generally the climax type of vegetation.

Decreasers are the species in the climax vegetation that decrease in relative amounts under continued heavy grazing. They generally are the most productive and palatable perennial plants.

Increasers are the species in the climax vegetation that generally increase in abundance as the more desirable plants are reduced by continued heavy grazing. These

[3] By HENRY NEAL STIDHAM, range conservationist, Soil Conservation Service.

TABLE 1.—*Estimated average acre yields of the crops commonly grown under two levels of management*

[Yields in columns A are those obtained over a number of years under common management; yields in columns B are those to be expected under improved management. Absence of a yield figure indicates that the crop is seldom grown, or that the soil is not suited to the crop specified, or that the soil is not arable]

Soil	Wheat		Corn		Soybeans		Oats		Barley		Grain sorghum		Alfalfa	Tame pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Lbs. beef* [1]	*Lbs. beef* [1]
Alluvial land															
Bates loam, 1 to 3 percent slopes	18	24	28	40	14	23	29	48	27	41	31	37	2	150	275
Bates loam, 3 to 5 percent slopes	15	20	23	34	12	20	23	39	22	35	24	33		125	250
Bates loam, 2 to 5 percent slopes, eroded	13	18					21	37	20	33	21	29		100	225
Bates loam, shallow	11	16					20	33	19	31	21	27		100	225
Baxter silt loam, 1 to 3 percent slopes	13	21	28	40	13	21	26	41	25	39	25	36		150	250
Baxter silt loam, 3 to 5 percent slopes	11	16	23	34	9	16	21	35	20	34	24	31		125	225
Bodine cherty silt loam, 0 to 3 percent slopes	10	17	22	33	11	19	20	33	19	32	24	29		125	225
Bodine very cherty silt loam, 1 to 8 percent slopes														100	200
Bodine stony silt loam, steep															
Breaks-Alluvial land complex															
Choteau silt loam, 0 to 1 percent slopes	21	30	33	50	15	25	33	50	31	48	33	50	2½	150	275
Choteau silt loam, 1 to 3 percent slopes	21	30	31	48	12	22	33	50	31	48	31	48	2½	150	275
Collinsville soils															
Craig silt loam, 1 to 3 percent slopes	14	23	28	39	11	19	30	44	29	41	27	44		150	275
Craig silt loam, 3 to 5 percent slopes	12	20	26	36	10	17	27	41	26	36	25	41		150	275
Dennis silt loam, 0 to 1 percent slopes	21	30	30	45	13	23	33	50	31	48	33	50	2	150	275
Dennis silt loam, 1 to 3 percent slopes	21	30	28	42	12	21	30	46	29	45	31	48	2	150	275
Dennis silt loam, 3 to 5 percent slopes	17	24	26	37	11	19	28	41	27	40	27	41		125	225
Dennis silt loam, 2 to 5 percent slopes, eroded	13	19					23	35	22	34	20	33		125	225
Eldorado soils															
Etowah silt loam, 0 to 3 percent slopes	14	23	33	54	21	28	29	43	27	41	32	46	2¾	200	400
Etowah gravelly silt loam, 3 to 8 percent slopes	12	18	27	39	16	22	22	35	21	33	26	37		175	325
Huntington gravelly silt loam	14	22	36	43	17	25	27	40	26	39	31	46		150	300
Huntington silt loam	23	29	46	55	21	30	31	47	31	45	34	51	2¾	200	400
Kaw silty clay loam	26	33	48	70	24	33	36	55	33	52	39	55	3	200	400
Lawrence silt loam	15	23	26	38	9	17	23	34	22	33	27	41		125	225
Lightning silt loam	12	15	18	30			21	32	20	31	31	40		100	200
Mine pits and dumps															
Newtonia silt loam, 1 to 3 percent slopes	19	29	31	44	13	22	31	47	29	45	31	47	2¾	150	275
Newtonia silt loam, 3 to 5 percent slopes	18	26	23	35	11	19	27	43	24	40	27	42		150	250
Newtonia silt loam, 2 to 5 percent slopes, eroded	13	21					21	34	20	33	21	33		124	225
Newtonia-Sogn complex															
Osage silty clay	12	15	18	30			21	32	20	31	31	40		100	200
Parsons silt loam, 0 to 1 percent slopes	18	27	23	32	10	17	30	39	26	37	24	35		100	200
Parsons silt loam, 1 to 3 percent slopes	17	25	21	29	8	15	21	32	20	31	21	32		100	200
Parsons silt loam, 1 to 3 percent slopes, eroded	11	17					15	24	14	23	17	24		75	150
Riverton gravelly loam, 3 to 5 percent slopes	13	18	23	34	11	19	31	38	30	36	31	39		150	275
Summit silty clay loam, 1 to 3 percent slopes	20	28	27	36	12	21	29	43	28	38	27	38		150	275
Taloka silt loam, 0 to 1 percent slopes	20	31	26	39	14	23	31	44	29	43	31	46		125	225
Verdigris silt loam	26	33	43	64	24	33	36	55	33	52	39	55	3	200	400
Woodson silty clay loam, 0 to 1 percent slopes	12	19	21	29	10	17	27	39	25	37	24	35		100	200
Woodson silty clay loam, 1 to 3 percent slopes	12	19	20	27	8	14	27	39	25	37	21	32		100	200

[1] Gain in pounds for one animal during one growing season.

plants are commonly shorter, less productive, and less palatable to livestock than the decreaser plants. Under prolonged heavy grazing, these plants commonly dominate the site.

Invaders are species that do not grow naturally on the specific site. These plants cannot withstand the competition for moisture, plant nutrients, and light in the climax vegetation. Hence, they come in and grow along with the increasers after the climax vegetation has been reduced by grazing.

Range condition, the present state of the vegetation on a particular site in relation to the climax vegetation for that site, is a method of rating deterioration of range. The purpose of the ratings is to establish a basis for predicting the degree of improvement possible under good management.

Four range condition classes are defined. A range is in *excellent condition* if 76 to 100 percent of the vegetation is of the same kind as in the original stand. It is in *good condition* if the percentage is between 51 to 75 percent, in *fair condition* if the percentage is between 26 and 50, and in *poor condition* if the percentage is less than 25.

Plant composition is the basis for determining the condition class of a range site. Farmers and ranchers need to become familiar with the kinds of plants on their different range sites. Then they can estimate the relative production, by weight, of the species present. The condition of the range can be determined any day of the year. If the farmer or rancher has studied the various sites, he can determine the condition of the range in areas that are grazed by comparing the present vegetation with his judgment of how the range would appear after a rest of one growing season. Condition class guides are maintained in the local work unit office of the Soil Conservation Service to help the farmer and rancher in determining the condition of his range.

Descriptions of range sites

In the pages that follow, the range sites of this county are described and the soils in each site are listed. Also listed are the principal plants when the range is in excellent condition and the plants that become abundant when the range is misused. Alluvial land, Huntington gravelly silt loam, Huntington silt loam, Lawrence silt loam, and Mine pits and dumps were not assigned to a range site because they are not suited to range.

CLAYPAN PRAIRIE SITE

This site consists of soils that have a surface layer of silt loam or silty clay loam and a subsoil of very compact clay. The subsoil is very slowly permeable. It restricts the penetration of moisture and hinders the growth of roots. The soils in this site are—

Parsons silt loam, 0 to 1 percent slopes.
Parsons silt loam, 1 to 3 percent slopes.
Parsons silt loam, 1 to 3 percent slopes, eroded.
Woodson silty clay loam, 0 to 1 percent slopes.
Woodson silty clay loam, 1 to 3 percent slopes.

Predominant when the range is in excellent condition are big bluestem, little bluestem, switchgrass, Indiangrass, gayfeather, and native legumes. In areas overgrazed, dropseed, jointtail, silver bluestem, broomsedge, and ragweed are abundant.

LOAMY PRAIRIE SITE

The soils in this site are medium textured or moderately fine textured, are nearly level to strongly sloping, and are on uplands. They have slow to moderately rapid permeability. These soils have good moisture-storage capacity and good depth for development of plant roots. The soils in this site are—

Bates loam, 1 to 3 percent slopes.
Bates loam, 3 to 5 percent slopes.
Bates loam, 2 to 5 percent slopes, eroded.
Bates loam, shallow.
Breaks-Alluvial land complex.
Choteau silt loam, 0 to 1 percent slopes.
Choteau silt loam, 1 to 3 percent slopes.
Craig silt loam, 1 to 3 percent slopes.
Craig silt loam, 3 to 5 percent slopes.
Dennis silt loam, 0 to 1 percent slopes.
Dennis silt loam, 1 to 3 percent slopes.
Dennis silt loam, 3 to 5 percent slopes.
Dennis silt loam, 2 to 5 percent slopes, eroded.
Eldorado soils.
Newtonia silt loam, 1 to 3 percent slopes.
Newtonia silt loam, 3 to 5 percent slopes.
Newtonia silt loam, 2 to 5 percent slopes, eroded.
Newtonia-Sogn complex (Newtonia part).
Riverton gravelly loam, 3 to 5 percent slopes.
Summit silty clay loam, 1 to 3 percent slopes.
Taloka silt loam, 0 to 1 percent slopes.

The soils in this site are the most productive in the uplands (fig. 6). When the site is in excellent condition, big bluestem, little bluestem, switchgrass, Indiangrass, gayfeather, ashy sunflower, and leadplant are the principal decreasers. If the range is in poor condition, jointtail, purpletop, dropseed, broomsedge, windmillgrass, silver bluestem, ragweed, and ironweed are abundant.

SHALLOW PRAIRIE SITE

Collinsville soils is the only mapping unit in this range site. These are shallow soils developed from noncalcareous sandstone. Plant-soil-moisture relationship is fair.

Yields of forage are good on this site in years when the supply of moisture is favorable. When the site is in excellent condition, big bluestem, little bluestem, Indiangrass, switchgrass, Canada wildrye, Tephrosia, sensitivebrier, and perennial sunflowers are the dominant decreasers. Side-oats grama, dropseed, coralberry, sumac, and persimmon are abundant when the site is in poor condition.

VERY SHALLOW SITE

Only the Sogn soils, which are part of the Newtonia-Sogn complex, are in this range site. Sogn soils are loamy and are very shallow and have formed over limestone. In places they have limestone flagstones on the surface. The soils are droughty, and their moisture-storage capacity is limited. Space for growth of roots is also limited. Sogn soils are the very shallow part of the Newtonia-Sogn complex; the Newtonia part of the complex is in the Loamy Prairie range site.

Yields of forage are low on the Very Shallow range site. The dominant plants are side-oats grama, silver bluestem, broomweed, ragweed, beebalm, and pricklypear.

***Figure 6.*—Loamy Prairie range site; this range site is highly productive if it is grazed moderately.**

STEEP CHERT SAVANNAH SITE

Bodine stony silt loam, steep, is the only soil in this range site. This soil is cherty, steep to very steep, and rapidly permeable. It is underlain by beds of chert. As a result, drainage through the soil is rapid and little moisture is available for plant growth.

Stones and poor water-holding capacity limit yields on this site. If the site is well managed, big bluestem, little bluestem, and Indiangrass are dominant in openings of stands of post oak, red oak, blackjack oak, white oak, and black locust. Also common on this site are dogwood trees, huckleberry bushes, and grapevines. On areas that have deteriorated, the vegetation is brushy blackjack oak, post oak, sassafras, and persimmon intermixed with broomsedge and poverty oatgrass.

SMOOTH CHERT SAVANNAH SITE

This site consists of deep, nearly level to moderately sloping, medium-textured soils that are well drained and are on the uplands. Most of the soils have a surface layer of silt loam and a subsoil of clay loam. The subsoil is generally cherty. As a result, the soils have limited water-holding capacity. The soils in this site are—

Baxter silt loam, 1 to 3 percent slopes.
Baxter silt loam, 3 to 5 percent slopes.
Bodine cherty silt loam, 0 to 3 percent slopes.
Bodine very cherty silt loam, 1 to 8 percent slopes.
Etowah silt loam, 0 to 3 percent slopes.
Etowah gravelly silt loam, 3 to 8 percent slopes.

This site has a higher production than any other site in the chert area. If it is well managed, good yields of big bluestem, little bluestem, Indiangrass, and purpletop can be expected. Other plants in the climax vegetation are post oak, blackjack oak, elm, red oak, black locust, black walnut, shortleaf pine, and hickory. When the range site is in poor condition, the principal increasers are persimmon, ash, post oak, blackjack oak, and sassafras. Other increasers are broomsedge and ragweed.

LOAMY BOTTOMLAND SITE

This site is made up of deep, nearly level, moderately permeable or slowly permeable soils that are subject to flooding in places. The soils take in mositure readily and store large quantities of water for plants. The soils in this site are—

Kaw silty clay loam.
Verdigris silt loam.

Yields of forage are high on this site in seasons when the areas are not flooded. When the range is in excellent condition, the principal decreasers are big bluestem, eastern gamagrass, prairie cordgrass, Florida paspalum, broadleaf uniola, poison ivy, and trumpet creeper. If the range is in poor condition, giant ragweed, goldenrod, sumpweed, and morning glory increase as the desirable grasses are killed out.

Desirable trees on this site are pecan, walnut, and ash. On areas that have deteriorated, elm and ash increase when the pecan and walnut are removed.

HEAVY BOTTOMLAND SITE

This site is made up of deep, poorly drained, very slowly permeable, alluvial soils. These soils are subject to flooding. They have a surface layer of silt loam or silty clay and a subsoil of dense clay. Soils in this site are—

Lightning silt loam.
Osage silty clay.

Yields of forage are high on this site if the areas are not flooded. The climax vegetation consists of river switchgrass, eastern gamagrass, prairie cordgrass, broadleaf uniola, and sedge. Elm, ash, walnut, pecan, poison ivy, and grapevines are common woody plants. When the range is in poor condition, giant ragweed, sumpweed, goldenrod, aster, sedges, rushes, and scrubby hardwoods are abundant.

Estimated production of herbage

Research and other data on actual herbage production for the soils and range sites in the county are limited. So that the operator will have a better understanding of the relative productivity of his range sites, the estimated annual production of herbage on the range sites in Ottawa County is shown in table 2. The yield estimates of herbage are based on recent clippings. They are for both favorable and unfavorable climatic cycles and are for range sites in excellent condition. One or two extremely favorable years, in a series of years when the climatic cycle is favorable, might push yields higher. Likewise, extreme drought could result in lower annual yields than are shown for the unfavorable climate. These estimated yields are based on total air-dried herbage that was clipped to ground level. Normally, in considering actual usable forage or mowed hay, the amount of forage will be considerably less than is shown.

TABLE 2.—*Estimated average acre yields of herbage in years of favorable and unfavorable climatic cycles*

Range site	Total herbage in years of—	
	Favorable season	Unfavorable season
UPLAND SITES		
	Lb. per acre	*Lb. per acre*
Claypan Prairie	5, 000	2, 500
Loamy Prairie	7, 500	4, 000
Shallow Prairie	4, 500	2, 500
Very Shallow	2, 500	1, 000
Smooth Chert Savannah	4, 500	2, 500
Steep Chert Savannah	3, 500	2, 000
BOTTOMLAND SITES		
Heavy Bottomland	8, 000	3, 000
Loamy Bottomland	10, 500	6, 000

Principles of range management

The basic purpose of good range management is to increase the number of the best forage plants and to encourage their growth. Following is a discussion of the main practices needed to achieve this purpose.

Proper grazing use.—Grazing the range at an intensity that maintains cover that is adequate to protect the soil and that maintains or improves the quantity and the

quality of desirable vegetation is the most important of all range practices. If a vigorous, healthy stand of desirable grasses is to be maintained and high yields obtained, not more than one-half of the annual growth of the main decreaser plants in the range site can be removed by grazing.

Grasses manufacture in their green leaves the food they need to grow, flower, and reproduce. If too much of this green foliage is removed by grazing, the plants are weakened and their growth is stunted. Moderate grazing, on the other hand, does not cause deterioration of desirable plants.

Generally, the operator who has studied his range sites knows the main decreaser grasses and understands signs that show improvement or mark the decline of a particular site. Such knowledge is necessary in adjusting grazing to improve the condition of the range. Specific guides for stocking rates are not included in this report. However, local representatives of the Soil Conservation Service or other agencies will help the operator estimate starting stocking rates.

Deferred grazing.—Periodically postponing, or deferring grazing, is a good way to speed the recovery of overgrazed range if a sufficient number of desirable plants are present in the site (fig. 7). Deferment should start at the beginning of the growing season of native grass, generally about the first part of April, and continue to the middle of October. This rest period gives the decreasers, such as big bluestem, little bluestem, switchgrass, and Indiangrass and desirable legumes and forbs, a chance to increase in the stand and crowd out less desirable plants. Deferment from around the middle of July until harvest time will allow seed harvest if the weather is favorable. If desirable plants are not present in the site, deferment should be accompanied by range seeding.

Range seeding.—It is desirable to seed perennial grasses to idle cropland that is returning to pasture or to overgrazed range that will not return to good bluestem grasses during a reasonable deferment (fig. 8). The seeding mixture should consist of big bluestem, little bluestem, switchgrass, and Indiangrass. Generally, seeding is done in a clean-tilled seedbed, but good results can be obtained if the seed is drilled in sorghum stubble. Proper preparation of the seedbed, use of good quality seed (fig. 9), control of weeds and brush, and deferring grazing for two growing seasons are needed in establishing highly productive pastures of native grass.

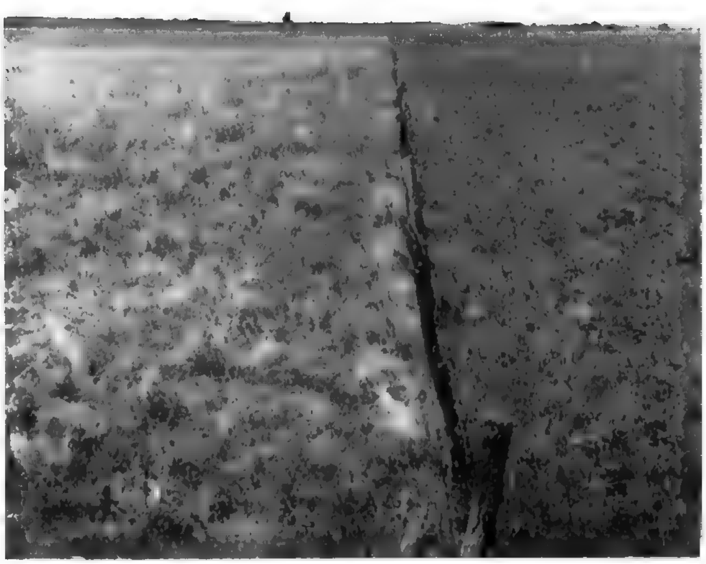

Figure 7.—**Deferred grazing of the range on the left side of the fence has maintained an excellent stand of desirable plants.**

Figure 8.—**Bluestem pasture on land formerly in low-yielding corn.**

Control of brush.—On some overgrazed range sites, thick stands of brush are encroaching and crowding out or suppressing the desirable native plants. In such areas brush can generally be controlled by spraying the foliage and keeping livestock out of the areas for two grazing seasons (fig. 10). Moderate grazing in winter when the plants are dormant, however, helps bear the cost of spraying and does not hurt the grass in the stand.

Water development and salting.—Water facilities and salt for livestock should be located to encourage uniform grazing. Grazing may be severe around the places where salt or water is located, even though some areas in the same pasture are lightly grazed. Generally, salt needs to be located away from water or other areas that are grazed heavily. Also, the salt should be moved periodically and new ponds or watering sources should be developed to draw the livestock into areas that are lightly grazed (fig. 11). Fencing the different kinds of pastures is costly, but it can be used if water development and salting practices fail.

Native hay meadows.—About 13,000 acres of native bluestem is harvested for hay annually. In most meadows the soils are gently sloping and have few stones on the surface that hinder mowing and raking. Generally, meadows in this county receive better management than native grass pastures.

Figure 9.—Native grass of good quality harvested for seed or to provide cash for the farmer.

Figure 10.—Woody plants of low value can be suppressed by spraying with herbicides. Thus, moisture and plant food are released and sunshine is admitted for the production of bluestem grasses of high value.

Figure 11.—Locating a stock pond in the part of the pasture that is lightly used helps to distribute grazing.

As a general rule, meadows on the uplands are cut once each year late in June or early in July, which allows time for the desirable grasses to regrow before frost and helps them maintain a vigorous stand. On the other hand, if a single cutting is made in August or September, the hay is stemmy and of low nutritive value. Repeated late annual mowing or double mowing reduces the vigor of grasses in the meadows and lowers the quality of the hay.

Almost all plant food is manufactured in the green leaves of the grass. Therefore, the cutter bar on the mowing machine used on native meadows should be set to a height of 3 or 4 inches above the soil surface or above the first joint of the grass. In this way, regrowth is encouraged and the recovery of the grass is hastened.

Many meadows that are mowed early in summer can be grazed in winter without damage to the stand if grazing is light and is done when the soil is firm.

Range site and range condition classes are determined on native hay meadows by the same system as that used on native range.

Woodland [4]

In Ottawa County, according to an inventory of conservation needs, woodland on farms occupies 82,900 acres, or about 28 percent of the total land in farms. All of the woodland is owned by farmers, ranchers, or other private owners. The holdings are all less than 5,000 acres and most of them are less than 500 acres each. Farm woodlots average less than 50 acres per farm. There are no State or National forests in the county, and none of the woodland is owned by the forest industry.

The principal areas of woodland are bounded on the north, east, and south by the boundaries of the county, and on the west by the Spring River and the Lake of the Cherokees. Most of the acreage is in the eastern part of the county on the steeper cherty soils of the Ozark Highlands and along the Neosho and Spring Rivers and their tributaries.

Shortleaf pine makes up about 3 percent of the commercially valuable trees. There is some eastern redcedar in the county. Among the more valuable hardwoods in the county are white oak, northern red oak, southern red oak, pin oak, sycamore, hard maple, black walnut, white ash, pecan, and black cherry. Other hardwoods are green ash, scalybark hickory, post oak, black oak, black locust, and American elm.

The soils in the county differ in their suitability for trees. Native hardwoods of good quality are predominant on the north slopes of the cherty ridges, along major streams, and in other areas where the soil-mosture conditions are above average for the county. Shortleaf pines grow on the south slopes of the cherty ridges, generally in a mixture with oaks, hickories, and other upland hardwoods.

Trees have been planted mainly for posts and to provide areas for wildlife. Only minor interest has been shown, however, in conserving and managing the stands of native timber or to planting pine on the soils of the Ozark Highlands, soils to which pine is well adapted. Providing protection from fire, controlling grazing, and using other good management are necessary for the improvement of the woodlands in the county.

[4] By CHARLES P. BURKE, woodland conservationist, Soil Conservation Service.

Potential soil productivity for woodcrops is rated by determining the average site index of different soils. Site index is determined by measuring the total height, attained at 50 years of age, under nearly ideal spacing of representative trees of the dominant species. Some sites are suited to pine and some to hardwood. A discussion of the sites suitable for pine and of those suitable for hardwood is given in the paragraphs that follow.

Pine.—Nearly all of the shortleaf pine that remains in the county is growing on Bodine stony silt loam, steep. Other soils in the county are also suitable for pine, however, and similar soils in adjacent counties in Oklahoma and Arkansas, under a similar climatic environment, have pine growing on them. Soils that are suitable for pine (fig. 12) in Ottawa County and the site index for each follow:

	Site index
Bodine cherty silt loam, 0 to 3 percent slopes	53
Bodine stony silt loam, steep	56
Bodine very cherty silt loam, 1 to 8 percent slopes	48
Baxter silt loam, 1 to 3 percent slopes	66
Etowah silt loam, 0 to 3 percent slopes	60

Table 3 shows yields that can be expected from well-managed stands of even-aged southern pine. The yields are based on 85 percent full stocking and on cutting at the age indicated.

TABLE 3.—*Yields that can be expected from well-managed stands of even-aged southern pine*

Site index	Cut at age	Average diameter	Total stand volume	Volume harvested	Volume remaining
	Years	*Inches*	*Cords*	*Cords*	*Cords*
50	18	6	9. 15	2. 79	6. 36
	27	8	15. 91	4. 25	11. 66
	36	10	21. 65	5. 07	16. 58
			Bd. ft.	*Bd. ft.*	*Bd. ft.*
	45	12	5, 100	1, 080	4, 020
			Cords	*Cords*	*Cords*
60	16	6	10. 48	3. 20	7. 28
	24	8	17. 73	4. 74	12. 99
	32	10	23. 31	5. 46	17. 85
			Bd. ft.	*Bd. ft.*	*Bd. ft.*
	40	12	5, 610	1, 188	4, 422

Hardwoods.—Areas of Etowah, Huntington, and Verdigris soils, along streams and on terraces, support commercial red and white oaks. These trees also grow on the north slopes of ridges on soils of the Baxter, Bodine, and Etowah series that are also suited to shortleaf pine. The principal hardwoods planted for posts are catalpa, black locust, and bois d'arc.

Soils that are suitable for catalpa trees are level or nearly level, moderately deep to deep, permeable, and well drained. The sites should not be subject to frequent flooding. In this county the Etowah, Huntington, and Verdigris soils on benches and bottom lands provide suitable sites for catalpa trees.

Soils suitable for catalpa trees are also suitable for black locust. In addition, black locust can be planted on Bates, Baxter, Craig, and Newtonia soils, on Bodine cherty silt loam, 0 to 3 percent slopes, and on Bodine very cherty silt loam, 1 to 8 percent slopes. Black

Figure 12.—**A good stand of shortleaf pine seedlings on Bodine very cherty silt loam, 1 to 8 percent slopes.**

locust should be planted for posts on the Newtonia silt loams only where depth to the parent material is more than 60 inches. Eroded sites should be avoided for the planting of black locust.

Bois d'arc can be planted for posts on prairie soils that are deep and are moderately and slowly permeable. It can also be planted on the bottom lands consisting of the Kaw and Verdigris soils.

If trees planted for posts are planted in suitable soils at the rate of 1,200 trees per acre, they can be expected to produce from 800 to 1,000 posts per acre at 10 or 12 years of age. An equal number of posts could be expected at 6-year intervals from sites planted to black locust or catalpa that are clear cut. Black locust and catalpa reproduce from stump sprouts, and the sprouts produced need to be thinned to two per stump. For good production of posts, the sites must be protected from fire and grazing.

Wildlife [5]

In Ottawa County there are three distinct kinds of wildlife habitats. Making up one habitat is the eastern third of the county, which is in the Ozark Highlands; another habitat is on the west side of Spring River and is in the Cherokee Prairies; the third habitat is made up of the bottom lands of the Neosho and Spring Rivers and their many small tributaries. Most of the wildlife species present in the county are common to all three habitats, but the numbers in each area vary greatly because of differences in the food and cover available.

Other than the many species of song and predatory birds, the species of wildlife most common in the county are bobwhite quail, cottontail rabbits, and fox and gray squirrels. A few prairie chickens still inhabit the small

[5] By HERBERT R. WELLS, soil conservationist, Soil Conservation Service.

areas of native prairie. A large number of northern bald eagles winter on the Lake of the Cherokees, where they are an attraction for many people. Among the predators are red and gray foxes and a few coyotes and bobcats. In places there are fair numbers of skunks, opossums, raccoons, muskrats, and mink. There are also a few colonies of beavers. Deer are numerous in the southeastern part of the county. Waterfowl occasionally are seen on the rivers and farm ponds, and sometimes large numbers of them winter on the Lake of the Cherokees.

The Ozark Highlands are rugged in many places and, therefore, have good potential for wildlife. The oak-hickory type of cover, the numerous springs, seeps, and clear streams, and the small fields used for agriculture make this section an excellent habitat for quail and for rabbits, squirrels, and other fur-bearing animals that like to live in wooded areas near open fields. Deer, foxes, and squirrels prefer the rougher sections of the Ozark Highlands. The primary needs in improving the Ozark Highlands for wildlife are controlling burning and developing a better understanding among the people of the requirements for the various kinds of wildlife and of the need for observing hunting regulations.

Among the native woody plants in the uplands and bottom lands of the Ozark Highlands that are important as a source of food for wildlife are red oak, white oak, various kinds of hickories and elms, black locust, ash, hard maple, soft maple, sassafras, persimmon, dogwood, blackberry and dewberry bushes, and grapevines. Birds and mammals throughout the area feed on acorns. The fruit of the chittam and hackberry provide food in midwinter for many birds and mammals. Early in spring when little other food is available for wildlife, the seeds of the elms and maples furnish a ready source of food. Browse is provided by dogwood, Jersey-tea, Virginia creeper, and wild grapevines.

Some of the grasses that furnish food and cover for wildlife in the Ozark Highlands are Indiangrass, switchgrass, wildrye, bluestem, and paspalum. In cool seasons bristlegrass, fescue, and bromegrass provide shelter and food. Ragweed, sunflower, legumes and similar native plants are also sources of food. Some of the common legumes preferred by wildlife are trailing wild bean, partridgepea, lespedeza, and species of the mimosa family.

In much of the Cherokee Prairies, the agriculture is based chiefly on the growing of small grain, so it would be expensive and difficult to develop adequate food and cover for wildlife. In this area most habitats for wildlife are on the bottom lands along the Neosho River and its tributaries. Protecting existing natural habitats on the bottom lands and fringe areas and planting but not harvesting small grain, corn, grain sorghum, and legumes adjacent to such areas would improve the bottom lands for wildlife.

In general, practices helpful in improving and developing wildlife habitats would include the following. Plant a suitable cover on areas that, because of size, shape, or location, are not adapted to other land use. Among such areas are corners, areas isolated by rights-of-way, streams, banks of streams, gullies, and areas around ponds. Protect existing natural habitats from fire and from overuse by livestock. Give particular attention to planting along fence rows, field borders, waterways, and other travel lanes, and along infrequently maintained county roads that connect wildlife areas.

***Figure 13.*—Multiflora rose furnishes good travel lanes for wildlife and also provides food for them.**

Where the soils are suitable for plants but the stand of desirable vegetation is poor, plant species that are useful for wildlife (fig. 13). If desirable woody plants are nearby, the soil should be cultivated lightly by disking or other suitable methods. In this way, useful annual seed-bearing weeds and grasses are encouraged to grow. If useful fruit, nut, or seed-bearing trees are present in dense stands of trees, thinning the stands encourages their growth.

Clearing occasional strips through the woods to establish the edge areas so favored by wildlife would improve some habitats. In areas where brush is being removed, leave uncut at least 10 percent of the brush in strips or clumps. Particularly leave plum, black cherry, sumac, chittam, hackberry, elm, oak, and cottonwood. Preserve den trees. If additional browse is needed, the amount of browse can be increased by cutting trees that sprout quickly.

Waterfowl can be attracted to ponds and lakes by diking the shallow areas and installing automatic gates to control the water level and then planting food for wildlife along the shoreline and flooding the areas in fall. On the uplands, establishing sanctuaries near farm ponds and other bodies of water and planting field crops near them would help to hold waterfowl in the areas.

There are about 1,400 farm ponds in the county. In about half of these and in the Lake of the Cherokees, fishing is fair to excellent. In the different streams largemouth or smallmouth bass are present, the species depending on the character of the water. Bullheads, bluegill, and green sunfish are abundant in most waters. Plentiful in the Lake of the Cherokees and in the large streams are crappie, channel and flathead catfish, carp, and buffalofish.

Runoff from cultivated areas or from roadside ditches that lack a cover of plants is likely to cause turbidity in farm ponds. The resulting muddy water prevents growth of aquatic plants, which provide food for the fish. Diverting muddy runoff water away from the ponds and revegetating cultivated areas near the ponds is necessary to keep the ponds suitable for fish. Adding organic matter, chemical fertilizer, or gypsum also helps to clear muddy water.

A farm pond should be stocked with desirable kinds of fish. Then the pond should be fertilized systematically so that desirable plants flourish and undesirable weeds are

controlled. The pond should also be fished regularly. In this way, the maximum size and number of fish the pond can support will be maintained. A well-managed farm pond contributes much to the recreational needs of the people of the county and also adds much high-quality protein to their food.

Continued guard against water pollution is needed on the large lakes. Also, fishing should be encouraged and the number of undesirable fish controlled.

Engineering Uses of the Soils [6]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, texture, plasticity, and pH. Topography and depth to water table and bedrock are also important.

The information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing sites for industrial, business, residential, and recreational uses.
2. Make estimates of the engineering properties of soils for use in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, and other material for use in construction.
5. Correlate performance of engineering structures with soil mapping units, and thus develop information for overall planning that will be useful in designing and maintaining the structures.
6. Determine the suitability of soils for the cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps, reports, and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It is not intended that this report will eliminate the need for on-site sampling and testing of the soils for design and construction of specific engineering works. The interpretations in the report should be used primarily in planning more detailed field investigations to determine the in-place condition of the soil at the proposed site for engineering works.

Some of the terms used by the soil scientist may not be familiar to the engineer, and some terms may have special meanings in soil science. Most of these terms, as well as other special terms that are used in the soil survey report, are defined in the Glossary in the back of the report.

Engineering soils classification, interpretations, and soil test data

To be able to make the best use of the soil maps and the soil survey report, the engineer should know the physical properties of the soil materials and the in-place condition of the soils. Tables 4, 5, and 6 summarize the physical properties and the suitability of the soils in Ottawa County for engineering works.

Table 4 lists the soils mapped, gives a brief description of the soils and estimates of some of their physical and chemical properties that affect engineering work. The properties are based on a typical profile for each soil series. The thickness of each horizon is shown in the column headed "Depth from surface." Where test data are available, the data shown are based on test data obtained for the modal or typical profiles. Where tests were not performed, the estimates shown are based on test data obtained from similar soils in this county or on test data obtained from soils from other counties. Also, past experiences in engineering construction is considered. Since the estimates are only for the modal soils, considerable variation from these values should be expected. More complete profile descriptions are given in the section "Formation, Classification, and Morphology of Soils."

In table 4 soil texture is described according to (1) the classification used by the U.S. Department of Agriculture,[7] (2) the Unified classification, developed by the Corps of Engineers, U.S. Army,[8] and (3) the system used by the American Association of State Highway Officials (AASHO).[9]

In the system used by scientists of the Department of Agriculture, the texture of a soil horizon (layer) depends on the proportional amounts of the different sized mineral particles. The soil materials are identified as cobblestones, gravels, sands, silts, and clays. Rarely does a soil consist of only one particle size, but a particle size might so dominate a soil that it would exhibit the characteristics of material composed of that particle size. For example, a soil that consists of 40 percent clay is called *clay* and characteristically feels slick, sticky, and plastic when wet. The texture of a soil is closely associated with its workability, fertility, permeability, erodibility, and other important characteristics. Representative textural groups from finest to coarsest are: (1) fine-textured soils (*clay, silty clay, sandy clay*); (2) medium-textured soils (*loam, silt loam, very fine sandy loam*); and (3) coarse-textured soils (*loamy fine sand, loamy sand, sand*, and *coarse sand*).

[6] By W. D. Hardesty, engineer, Soil Conservation Service.

[7] United States Department of Agriculture. Soil survey manual. Agr. Handb. No. 18, 503 pp., illus. 1951.

[8] U.S. Army, Corps of Engineers. The unified soil classification system. Tech. Memo. 3-357, v. 1, illus. 1953.

[9] American Association of State Highway Officals. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 pts., illus. 1961.

TABLE 4.—*Brief description of the soils of Ottawa County,*

Map symbol	Soil	Description of soil and site	Depth from surface	Classification: USDA texture
			Inches	
Ad	Alluvial land.[1]	Mixture of alluvial soils of the Osage, Verdigris, and Huntington series; frequently flooded.		
BaB	Bates loam, 1 to 3 percent slopes.	Undulating to slightly rolling loams to clay loams that overlie rotten sandstone and sandy shale; bedrock at a depth of 2 to 3 feet.	0–13	Loam
BaC	Bates loam, 3 to 5 percent slopes.		13–18	Heavy loam
BaC2	Bates loam, 2 to 5 percent slopes, eroded.		18–33	Light clay loam or sandy clay loam.
Bb	Bates loam, shallow.	Similar to Bates loams, but all of the horizons are thinner and bedrock is at a depth of 1½ feet.	0–10	Loam
			10–17	Light clay loam or sandy clay loam.
BcB	Baxter silt loam, 1 to 3 percent slopes.	About 2 feet of silt loam that grades to a layer of clay that is about 6 inches thick; below is very cherty silty clay that is 1 to several feet thick and rests on cherty limestone.	0–15	Silt loam
			15–25	Silty clay
BcC	Baxter silt loam, 3 to 5 percent slopes.		25–31	Cherty clay
			31–50+	Very cherty silty clay
BdB	Bodine cherty silt loam, 0 to 3 percent slopes.	Upland soil of cherty silt loam that grades to very cherty silty clay loam; bedrock is at a depth of about 10 feet; excessively drained.	0–21	Cherty silt loam
			21–60	Very cherty silty clay loam
BnD	Bodine very cherty silt loam, 1 to 8 percent slopes.	Mostly strongly sloping soils that are very cherty throughout the profile; depth to bedrock is about 10 feet.	0–16	Very cherty silt loam
BoE	Bodine stony silt loam, steep.		16–60	Very cherty silty clay loam
Br	Breaks-Alluvial land complex.	V-shaped drainageways; loamy soils on the side slopes and silt loams or clay loams in the bottoms of the drainageways.	([1])	Loam to silty clay loam
ChA	Choteau silt loam, 0 to 1 percent slopes.	Nearly level to gently sloping upland soils that consist of silt loam over silty clay loam; formed in old alluvium; depth to bedrock is about 8 feet; well drained.	0–22	Silt loam
			22–40	Silty clay loam
ChB	Choteau silt loam, 1 to 3 percent slopes.		40–46	Light silty clay loam
Co	Collinsville soils.	Undulating to hilly soils; the soils consist of a thin mantle of soil material on disintegrated sandstone.	0–7	Loam
CrB	Craig silt loam, 1 to 3 percent slopes.	About 2 feet of silt loam over silty clay loam; below is gravelly clay loam; depth to bedrock is about 8 feet.	0–16	Silt loam
			16–22	Light silty clay loam
CrC	Craig silt loam, 3 to 5 percent slopes.		22–26	Gravelly clay loam
			26–30+	Very cherty light silty clay loam.
DnA	Dennis silt loam, 0 to 1 percent slopes.	Nearly level to moderately sloping upland soils; the surface layer is silt loam and grades to a subsoil of heavy clay loam; depth to bedrock ranges from 3 to 8 feet.	0–14	Silt loam
			14–18	Light silty clay loam
DnB	Dennis silt loam, 1 to 3 percent slopes.		18–29	Clay loam
			29–42+	Heavy clay loam
DnC	Dennis silt loam, 3 to 5 percent slopes.			
DnC2	Dennis silt loam, 2 to 5 percent slopes, eroded.			
Ed	Eldorado soils.	Gently sloping to strongly sloping soils; the slope is 1 to 8 percent; some of the areas are on narrow ridgetops; the soils are cherty and grade to an interbedded layer of fragments and ledges of chert that is 2 to 10 feet thick over bedrock.	0–14	Silt loam
			14–24	Very cherty light clay loam
			24–36	Cherty fragments and ledges.
EtA	Etowah silt loam, 0 to 3 percent slopes.	Soils on benches; derived from old alluvium; the profile is more gravelly with increasing depth; depth to bedrock is 10 feet or more.	0–6	Silty loam
			6–14	Gravelly silt loam
EhD	Etowah gravelly silt loam, 3 to 8 percent slopes.		14–25	Clay loam
			25 72+	Very gravelly clay loam
Hg	Huntington gravelly silt loam.	Nearly level alluvial soil; the profile is gravelly and rests on gravel; depth to bedrock is 8 to 10 feet; occasionally flooded.	0–11	Gravelly silt
			11–50+	Gravelly silty clay loam

See footnotes at end of table.

Okla., and their estimated physical and chemical properties

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential	Hydrologic soil group
Unified	AASHO	No. 4	No. 10	No. 200					
					Inches per hour	*Inches per inch of soil*	*pH value*		
----------	----------	----------	----------	----------	----------	----------	----------	Medium to high	C
ML	A 4	100	90–100	70–80	0. 8–2. 5	0. 12	6. 2–6. 6	Low to medium	B
ML–CL	A–4	100	90–100	70–80	0. 8–2. 5	. 14	5. 8–6. 2	Medium	
ML–CL	A–4	100	90–100	70–80	0. 8–2. 5	. 14	6. 0–6. 5	Low	
ML	A–4	100	90–100	70–80	0. 8–2. 5	. 12	6. 2–6. 6	Low to medium	B
ML–CL	A–4	100	90–100	70–80	0. 8–2. 5	. 14	6. 0–6. 5	Low to medium	
ML	A–4	90–100	80–90	70–80	0. 8–2. 5	. 14	5. 5–6. 0	Low to medium	B
ML–CL	A–6	90–100	80–90	80–90	0. 2–0. 8	. 18	5. 0–5. 5	Medium to high	
CL	A–7	60–70	60–70	60–70	0. 2–0. 8	. 14	5. 0–5. 5	Medium to high	
ML, GM	A–6	40–60	40–60	40–60	0. 8–2. 5	. 10	5. 0 5. 5	Medium to high	
ML, GM	A–4	60–80	60–80	60–70	2. 5–5. 0	. 14	4. 5–6. 0	Low	B
ML	A–6	40–60	40–60	40–60	0. 8–2. 5	. 10	4. 5–5. 2	Medium	
ML	A–4	40–60	40–60	40–60	2. 5–5. 0	. 07	5. 5–6. 5	Low	B
ML–CL	A–6	40–60	40–60	40–60	2. 5–5. 0	. 07	4. 5–5. 3	Low	
ML–CL	A 4 to A–6	100	90–100	90–100	([1])	----------	----------	Low to high	C
ML	A–4	100	90–100	80–90	0. 8–2. 5	. 14	5. 0–6. 5	Low	C
ML–CL	A–6	100	90–100	80–90	0. 05 0. 2	. 18	5. 0–5. 5	Medium to high	
ML	A–4	100	100	90–100	0. 2–0. 8	. 18	5. 8–6. 3	Medium	
ML	A–6	100	90–100	90–100	0. 8–2. 5	. 18	5. 8–6. 3	Low	C
ML	A–4	100	90–100	90–100	0. 8–2. 5	. 18	5. 8–6. 3	Low to medium	C
ML	A–6	90–100	90–100	80–90	0. 8–2. 5	. 18	5. 6–6. 1	Medium to high	
ML–CL	A–6	70–80	70–80	70–80	0. 8–2. 5	. 14	5. 6–6. 1	Medium to high	
ML	A–4	50–60	50–60	50–60	2. 5–5. 0	. 12	4. 8–5. 3	Medium to high	
ML	A–4	100	100	60–70	0. 8–2. 5	. 14	5. 3–5. 8	Medium to high	C
ML	A–4	100	100	70–80	0. 8–2. 5	. 18	4. 8–5. 3	Medium to high	
ML–CL	A–7	100	100	80–90	0. 05–0. 2	. 18	4. 8–5. 3	High	
ML–CL	A–7	100	100	80–90	0. 05–0. 2	. 18	5. 8–6. 3	High	
ML	A–4	100	90–100	90–100	0. 8–2. 5	. 14	----------	Low	B
CL, GC	A–6	40–60	40–60	40 60	2. 5 5. 0	. 10	----------	Low	
GM	A–1	10–20	10–20	10–20	2. 5–5. 0	----------	----------	Low	
ML–CL	A–4	80–90	80–90	55–75	0. 8–2. 5	. 14	4. 8–5. 3	Medium	B
GM	A–2 or A–4	40–50	40–50	30–40	5. 0–10	. 10	5. 3–5. 8	Medium	
CL	A–6	70–80	60–70	50–60	0. 8–2. 5	. 14	5. 3–5. 8	Medium	
GM–GC	A–2 or A–4	50–60	40–50	30–40	5. 0–10	. 10	5. 3–5. 8	Low to medium	
ML	A–4	60–70	50–60	50–60	0. 8–2. 5	. 12	5. 8–6. 3	Low	B
GM–GC	A–1 or A–2	10–25	10–25	10–25	2. 5–5. 0	. 07	5. 3–5. 8	Low to medium	

TABLE 4.—*Brief description of the soils of Ottawa County,*

Map symbol	Soil	Description of soil and site	Depth from surface	Classification
				USDA texture
			Inches	
Hu	Huntington silt loam.	Nearly level alluvial soil; the surface layer is silt loam and it grades to gravel; depth to bedrock is 8 to 10 feet; flooded about once each year.	0–12 12–50+	Silt loam Very gravelly silty clay loam
Ka	Kaw silty clay loam.	Nearly level, fine-textured alluvial soil derived from recent alluvial sediments; depth to bedrock ranges from 6 to 10 feet; flooded about once each year.	0–29 29–50+	Clay loam Clay loam
La	Lawrence silt loam.	Level to nearly level upland soil; the profile consists of medium- and fine-textured soil material; it is underlain by very cherty clay loam; the seasonal water table is at a depth of less than 3 feet; depth to bedrock is about 5 feet.	0–12 12–20 20–33 33–36	Silt loam Silt loam Clay Very cherty clay loam
Ln	Lightning silt loam.	Nearly level alluvial soil on flood plains; the seasonal water table is at a depth of less than 3 feet; bedrock is at a depth below 10 feet; flooding occurs once or twice each year.	0–18 18–60	Silty loam Silty clay
NaB NaC NaC2	Newtonia silt loam, 1 to 3 percent slopes. Newtonia silt loam, 3 to 5 percent slopes. Newtonia silt loam, 2 to 5 percent slopes, eroded.	Undulating and gently rolling upland soils; the profile of these soils consists of silt loam and silty clay; the parent material is limestone or cherty limestone; depth to bedrock is generally between 2 and 6 feet.	0–16 16–56 56–64 64–70+	Silty loam Silty clay loam Silty clay loam Cherty silty clay loam
Ns	Newtonia-Sogn complex.	Undulating to hilly upland soils; the areas are small and consist of intermingled areas of Newtonia silt loam and of Sogn soils; for the Newtonia component see Newtonia silt loam; the Sogn component consists of soils, 1 foot or less thick, that are underlain by limestone.	0–6 6–10	Clay Silty clay loam
Os	Osage silty clay.	Nearly level, clayey alluvial soil on flood plains; surface and internal drainage are poor; the seasonal water table is at a depth of 3 feet or less; depth to bedrock is more than 10 feet.	0–13 13–32 32–60+	Clay Clay Clay
PaA PaB PaB2	Parsons silt loam, 0 to 1 percent slopes. Parsons silt loam, 1 to 3 percent slopes. Parsons silt loam, 1 to 3 percent slopes, eroded.	Nearly level to gently sloping upland soils; below the silty surface layer the profile is heavy clay; depth to bedrock is about 10 feet; perched water table during wet seasons.	0–15 15–38 38–46+	Silty loam Clay Clay
RvC	Riverton gravelly loam, 3 to 5 percent slopes.	High, smooth areas near streams or in some places on the top of low hills; the profile is gravelly throughout; depth to bedrock is about 8 feet.	0–7 7–60	Gravelly loam Very gravelly loam
SuB	Summit silty clay loam, 1 to 3 percent slopes.	Gently sloping upland soil that is medium- to fine-textured throughout the profile; depth to limestone bedrock is about 4 feet.	0–20 20–30 30–42	Silty clay loam Clay loam Silty clay
TaA	Taloka silt loam, 0 to 1 percent slopes.	Nearly level upland soil; below the silty surface layer the profile is heavy clay; depth to bedrock is about 10 feet; perched water table during wet seasons.	0–20 20–46 46–56	Silty loam Clay Silty clay
Vd	Verdigris silt loam.	Nearly level, medium- and fine-textured alluvial soil on flood plains; derived from recent alluvium; depth to bedrock is about 15 feet.	0–25 25–60	Silty loam Silty loam
WoA WoB	Woodson silty clay loam, 0 to 1 percent slopes. Woodson silty clay loam, 1 to 3 slopes.	Nearly level to undulating upland soil; the profile is silty clay loam or clay; formed from weathered clayey shale; depth to bedrock is about 6 feet.	0–10 10–60	Silty clay loam Clay

[1] Variable. [2] Permeability is 0.05 inch or less per hour.

Okla., and their estimated physical and chemical properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential	Hydrologic soil group
Unified	AASHO	No. 4	No. 10	No. 200					
					Inches per hour	*Inches per inch of soil*	*pH value*		
ML-CL	A-4	90–100	90–100	80–90	0.8–2.5	0.14		Low to medium	B
GC	A-2	10–25	10–25	10–25	2.5–5.0	.07		Low	
ML-CL	A-7	100	100	80–90	0.8–2.5	.18	6.0–6.5	Medium to high	C
ML-CL	A-7	100	100	80–90	0.05–0.2	.18	5.8–6.3	Medium to high	
ML-CL	A-4	100	100	90–100	0.8–2.5	.14	5.8–6.5	Medium	D
CL	A-6	90–100	80–90	70–80	0.2–0.8	.18	4.2–4.8	Medium to high	
CL	A-7	80–90	80–90	70–80	0.05–0.2	.18	4.2–4.8	High	
CL or GC	A-4	40–60	40–60	40–60	2.5–5.0	.18	4.2–4.8	Medium	
ML-CL	A-6	100	100	90–100	0.8–2.5	.18	5.0–6.5	Medium	D
ML-CL	A-6	100	100	90–100	(2)	.18	4.5–5.3	Medium to high	
ML	A-4	100	100	80–90	0.8–2.5	.14	5.5–6.0	Medium	B
CL	A-4	100	100	80–90	0.8–2.5	.14	5.8–6.3	Low to medium	
ML-CL	A-7	100	100	90–100	0.2–0.8	.14	6.0–6.5	Low to medium	
ML	A-4	70–80	60–70	60–70	2.5–5.0	.10	6.0–6.5	Low to medium	
ML-CL	A-7	100	90–100	90–100	0.2–0.8	.14	6.5–7.0	Low to medium	C
ML-CL	A-7	100	90–100	90–100	0.2–0.8	.14	6.5–7.0	Medium	
MH	A-7	100	100	100	0.8–2.5	.18	5.8–6.3	High	D
MH or ML	A-7	100	100	100	(2)	.18	5.5–6.0	High	
CH	A-7	100	100	100	(2)	.18	6.8–7.3	High	
ML-CL	A-4	100	100	90–100	0.8–2.5	.18	5.0–5.5	Medium to high	D
CH	A-7	100	100	90–100	(2)	.18	6.0–6.5	High	
CH	A-7	100	100	90–100	(2)	.18	6.5–7.0	High	
ML	A-4	60–70	60–70	60–70	0.8–2.5	.10	5.3–5.8	Low to medium	B
GM	A-2	30–40	30–40	20–30	2.5–5.0	.07	5.0–5.5	Low to medium	
CL	A-4	100	100	90–100	0.8–2.5	.18	6.5–6.9	Medium	C
MH-CH	A-7	100	100	90–100	0.05–0.2	.18	6.8–7.3	High	
MH	A-7	100	100	90–100	0.05–0.2	.18	7.3–7.8	High	
ML	A-4	100	90–100	80–90	0.8–2.5	.14	5.5–5.8	Medium	D
CL, CH	A-6 or A-7	100	90–100	90–100	(2)	.18	5.0–6.0	High	
CL	A-6	100	90–100	80–90	(2)	.18	6.3–6.8	High	
ML	A-4	100	100	90–100	0.8–2.5	.14	6.0–6.5	Medium	B
ML	A-4	100	100	90–100	0.8–2.5	.14	5.8–6.3	Medium	
CL	A-6	100	100	90–100	0.05–0.2	.18	6.8–7.2	High	D
CL, CH	A-6 or A-7	100	100	90–100	(2)	.18	6.8–7.5	High	

TABLE 5.—*Interpretation of engineering properties*

Soils and map symbols	Suitability as source of—				Soil features affecting—
	Topsoil	Gravel	Select grading material	Road fill	Highway location
Alluvial land (Ad)	Good	Good source in stream bed in eastern third of the county.	Good to poor; areas of good and poor material are intermingled.	Good	Subject to frequent flooding.
Bates loam (BaB, BaC, BaC2).	Fair to good	Unsuitable; material is fine grained.	Fair to good for all material above bedrock.	Good	Sandstone and sandy shale bedrock at a depth of 2 to 3 feet; seepage on slopes.
Bates loam, shallow (Bb).	Poor to fair, but quantity of material is limited.	Unsuitable; material is fine grained.	Fair to good, but material is limited.	Good	Sandstone and sandy shale bedrock at a depth of 1 to 2 feet; seepage on slopes.
Baxter silt loam (BcB, BcC).	Fair to good; approximately 2 feet of good material; some scattered chert.	Fair source for county road surfacing at a depth below 2 feet.	Good, but a few chert fragments are larger than 3 inches across.	Good	Cherty profile below the surface layer.
Bodine cherty silt loam (BdB).	Poor to fair; but fragments in some places.	Fair source for county road surfacing.	Poor to fair; in some places chert fragments are more than 3 inches across.	Good	Cherty profile
Bodine very cherty silt loam (BnD), Bodine stony silt loam (BoE).	Poor; too much chert to establish and maintain vegetation.	Unsuitable	Poor because of high percentage of chert.	Good	Steep soils that are cherty throughout the profile.
Breaks-Alluvial land complex (Br).	Poor to fair; limited quantity of material on ravine slopes; soils too clayey in valley.	Unsuitable; material is fine grained.	Poor; material is limited.	Poor; material is limited and variable.	V-shaped drainageways.
Choteau silt loam (ChA, ChB).	Good	Unsuitable; material is fine grained.	Poor to fair; upper 22 inches suitable.	Good	Soil properties favorable.
Collinsville soils (Co)	Poor; material limited in quantity and generally stony.	Unsuitable; material is fine grained.	Poor; material is rocky and limited.	Poor; mostly sandstone.	Steep and stony soils; seepage along bedrock.
Craig silt loam (CrB, CrC).	Good	Good for county road surfacing at a depth below 2 feet.	Poor to fair; generally too plastic.	Good	Very cherty subsoil.
Dennis silt loam (DnA, DnB, DnC, DnC2).	Good	Unsuitable; material is fine grained.	Poor to fair; generally too plastic.	Fair	Plastic clay at a depth below 1½ feet.
Eldorado soils (Ed)	Poor; material limited and stony.	Unsuitable; material is fine grained.	Poor; areas small and generally steep and rocky.	Fair; limited soil material.	Bedrock near the surface in many places; steep slopes in some places.

of the soils in Ottawa County, Okla.

Soil features affecting—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Areas too small; too much drainage area.	Variable seepage; variable stability.	Areas too small to make drainage practical if needed.	Nonarable	Nonarable	Nonarable.
Limited depth in most places; variable seepage.	Variable seepage	Well drained	Topsoil depth limits grading.	Soil properties favorable; generally no limitations.	Soil properties favorable.
Limited depth to bedrock; high seepage.	Limited borrow material; variable seepage.	Well drained	Topsoil depth limits grading.	Bedrock is near the surface.	Bedrock near the surface; droughty.
Limited depth to beds of chert.	Stable; low seepage in chert-free material.	Well drained	Topsoil depth limits grading.	Soil properties favorable.	Soil properties favorable.
High seepage; limited depth to beds of chert.	High seepage; cherty material.	Well drained	Topsoil depth limits grading.	Very gentle slopes	Very gentle slopes, low fertility.
Very stony profile; high seepage.	Very stony material; high seepage.	Excessively drained	Poor agricultural soil; very rapid intake rate.	Very stony; limited agricultural use.	Very stony; limited agricultural use.
Generally no depth problems; low seepage.	Stable; no problems	Well drained	Broken topography	Nonarable	Steep slopes.
No depth problems; low seepage.	Soil properties favorable.	Slight drainage sometimes needed where natural drainage has been blocked.	Flat slopes suitable for flooding; steeper slopes suitable only for sprinkler irrigation.	Soil properties favorable.	Soil properties favorable.
Very shallow to bedrock; no suitable sites.	Limited borrow material; seepage along bedrock.	Excessively drained	Nonarable	Nonarable	Nonarable; limited depth to bedrock; droughty.
Variable seepage; no depth problems.	Soil properties favorable.	Well drained	Topsoil depth limits grading.	Soil properties favorable.	Soil properties favorable.
Low seepage; no depth problem.	Soil properties favorable.	Well drained	Flat slopes suitable for flooding; steeper slopes suitable only for sprinkler irrigation.	Soil properties favorable.	Soil properties favorable.
Stony profile; high seepage.	Stony material; high seepage.	Excessively drained	Nonarable	Nonarable	Stony; limited depth to bedrock; droughty.

TABLE 5.—*Interpretation of engineering properties*

Soils and map symbols	Suitability as source of—				Soil features affecting—
	Topsoil	Gravel	Select grading material	Road fill	Highway location
Etowah silt loam (EtA), and Etowah gravelly silt loam (EhD).	Good to fair	Good for county road surfacing at a depth below 2 feet.	Good	Good	Soil properties favorable.
Huntington gravelly silt loam (Hg).	Poor to fair; too much gravel.	Surface layer is poor; subsoil is suitable for county road surfacing.	Good, except some stones are more than 3 inches across.	Good	Subject to occasional flooding.
Huntington silt loam (Hu).	Good	Surface layer is poor; subsoil is suitable for county road surfacing.	Good	Good	Subject to occasional flooding; good at a depth below 1 foot.
Kaw silty clay loam (Ka).	Good	Unsuitable; material is fine grained.	Poor; highly plastic	Poor; highly plastic soil material.	Subject to occasional flooding; highly plastic soil material.
Lawrence silt loam (La).	Fair to good in the upper foot of soil material.	Unsuitable; material is fine grained.	Poor; highly plastic	Fair to poor; subsoil is highly plastic.	Highly plastic soil material; high water table; poor internal drainage.
Lightning silt loam (Ln).	Poor to fair; subsoil poor.	Unsuitable; material is fine grained.	Poor; highly plastic.	Poor; highly plastic soil material.	Highly plastic soil material; seasonal high water table; subject to occasional flooding.
Newtonia silt loam (NaB, NaC, NaC2).	Good	Unsuitable; material is fine grained.	Good	Good	Depth to bedrock 2 to 6 feet.
Newtonia-Sogn complex (Ns).	Poor; too rocky	Unsuitable; material is fine grained.	Poor; material is limited.	Poor; soil material is limited.	Limestone bedrock is near the surface in many places.
Osage silty clay (Os)	Poor; highly plastic	Unsuitable; material is fine grained.	Poor; highly plastic	Poor; highly plastic; high shrink-swell potential.	Highly plastic soil material; poorly drained; subject to flooding.
Parsons silt loam (PaA, PaB, PaB2).	Good in the upper foot of soil material; subsoil poor.	Unsuitable; material is fine grained.	Poor; highly plastic	Poor; highly plastic; high shrink-swell potential.	Highly plastic soil material; poor internal drainage
Riverton gravelly loam (RvC).	Poor; material is gravelly and limited.	Good for county road surfacing.	Good	Good	Soil properties favorable.
Summit silty clay loam (SuB).	Good	Unsuitable; material is fine grained.	Poor; highly plastic	Fair; moderate shrink-swell potential.	Highly plastic soil material; bedrock is at a depth of about 4 feet.

of the soils in Ottawa County, Okla.—Continued

Soil features affecting—					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Variable seepage; cherty material at a depth of less than 3 feet.	Variable seepage	Well drained	Topsoil depth limits grading.	Outlets difficult to establish; overhead water is a problem.	Soil properties favorable.
Very high seepage	High seepage	Well drained	Topsoil depth limits grading; subject to occasional overflow.	Not needed; soil is nearly level.	Low fertility; flat slopes.
Very high seepage	High seepage	Well drained	Suitable for flood irrigation with little grading; subject to occasional overflow.	Not needed; soil is nearly level.	Soil properties favorable; flat slopes.
Very low seepage; adequate depth.	Soil properties favorable.	Well drained	Suitable for flood irrigation with little grading; subject to occasional overflow.	Not needed; soil is nearly level.	Soil properties favorable; flat slopes.
Chert material at a depth below 3 feet.	Soil properties favorable.	Seasonal high water table.	Very slow intake rate; high water table.	Not needed; soil is nearly level.	Flat slopes; low fertility; droughty.
No impoundment sites; suitable only for dug ponds.	Soil properties favorable.	Needs complete surface drainage system; subject to damaging overflow.	Subject to flooding; very slow intake rate; poorly drained.	Not needed; soil is nearly level.	Nearly level soil; vegetation difficult to establish; subject to occasional flooding.
Variable seepage; variable depth to bedrock.	Stable; relatively impervious when compacted; high seepage.	Well drained	Topsoil depth limits grading.	Soil properties favorable; no problems.	Soil properties favorable; no problems.
Limited depth to bedrock.	Limited borrow material.	Excessively drained	Nonarable	Nonarable	Nonarable; soils are rocky.
Low seepage; sites limited to dug ponds.	Subject to severe cracking; low strength and stability.	Very slowly permeable; needs surface drainage; internal drainage poor; subject to flooding.	Very slow intake rate; subject to flooding; poorly drained; subject to cracking.	Not needed; soil is nearly level.	Subject to cracking; difficult to establish vegetation; soil is nearly level.
Low seepage; sites generally limited to dug ponds.	Low strength and stability; subject to severe cracking.	Very slowly permeable; poor internal drainage; simple drainage needed where natural drainage has been blocked.	Very slow intake rate; poor internal drainage.	Soil properties favorable; no problems.	Difficult to establish vegetation; droughty.
High seepage	High seepage	Well drained	Topsoil depth limits grading.	Material is gravelly; outlets difficult to establish.	Droughty.
Low seepage; adequate depth.	Soil properties favorable.	Well drained	Topsoil depth limits grading; subject to cracking.	Soil properties favorable.	Soil properties favorable; subject to cracking in some places.

TABLE 5.—*Interpretation of engineering properties*

Soils and map symbols	Suitability as source of—				Soil features affecting—
	Topsoil	Gravel	Select grading material	Road fill	Highway location
Taloka silt loam (TaA).	Good in the upper 20 inches of soil material; subsoil is poor.	Unsuitable; material is fine grained.	Poor; highly plastic	Poor; highly plastic; high shrink-swell potential.	Highly plastic soil material; poor internal drainage.
Verdigris silt loam (Vd).	Good	Unsuitable; material is fine grained.	Fair; erodible	Fair; erodible	Subject to occasional flooding.
Woodson silty clay loam (WoA, WoB).	Poor; highly plastic	Unsuitable; material is fine grained.	Poor; highly plastic	Poor; highly plastic; high shrink-swell potential.	Highly plastic soil material; poor internal drainage.

TABLE 6.—*Engineering test data for soil samples*

Soil name and location	Parent material	Oklahoma report number	Depth	Horizon	Shrinkage		Volumetric change from field moisture equivalent
					Limit	Ratio	
Dennis silt loam, 1 to 3 percent slopes:			*Inches*				*Percent*
0.6 mile S. of NE. corner sec. 14, T. 27 N., R. 22 E. (Modal profile.)	Shale and clay	SO-3459	0-14	A_1	25	1.57	9
		SO-3460	18-29	B_2	14	1.89	44
		SO-3461	29-42+	C	14	1.92	42
¼ mile N. of SE. corner sec. 29, T. 27 N., R. 22 E. (Nonmodal profile.)	Sandstone and shale	SO-3462	0-6	A_{1p}	22	1.65	6
		SO-3463	11-24	B_2	19	1.75	25
		SO-3464	24-40	C	18	1.79	34
Etowah silt loam, 0 to 3 percent slopes: 300 feet S. and 300 feet E. of NW. corner sec. 27, T. 28 N., R. 24 E. (Modal profile.)	Alluvium from cherty limestone.	SO-3450	0-6	A_{1p}	19	1.68	9
		SO-3451	14-25	B_2	16	1.84	26
		SO-3452 [5]	40 72	C	16	1.85	25
Newtonia silt loam, 1 to 3 percent slopes: Center of E. side of sec. 20, T. 27 N., R. 23 E. (Modal profile.)	Cherty limestone	SO-3456	0-7	A_{1p}	20	1.76	4
		SO-3457	16-30	B_2	18	1.79	13
		SO-3458	56-64	C	17	1.85	43
500 feet E. of NW. corner sec. 5, T. 25 N., R. 22 E. (Nonmodal profile.)	Cherty limestone	SO-3447	0-6	A_{1p}	23	1.67	2
		SO-3448	12-20	B_{21}	22	1.71	11
		SO-3449 [5]	20-32	B_{22}	19	1.74	14

See footnotes at end of table.

of the soils in Ottawa County, Okla.—Continued

Soil features affecting—					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Low seepage; sites limited to dug ponds.	Low strength and stability; subject to severe cracking.	Very slow permeability; poor internal drainage; simple drainage needed where natural drainage has been blocked.	Very slow intake rate; poor internal drainage.	Soil properties favorable.	Soil properties favorable.
Variable seepage; sites limited to dug ponds.	Soil properties favorable.	Well drained	Nearly level; moderate intake rate; subject to flooding.	Not needed; soil is nearly level.	Soil is nearly level; subject to overflow.
Low seepage; sites generally limited to dug ponds.	Low strength and stability; subject to severe cracking.	Very slow permeability; poor internal drainage; simple drainage needed where natural drainage has been blocked.	Very slow intake rate; topsoil depth limits grading.	Soil properties favorable.	Droughty; difficult to establish vegetation.

taken from seven soil profiles in Ottawa County, Okla.[1]

Mechanical analysis										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—							Percentage smaller than—						
1 in.	¾ in.	⅜ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.			AASHO[3]	Unified[4]
				100	98	69	60	13	9	33	6	A-4(7)	ML.
				100	99	83	74	43	37	43	17	A-7-6(12)	ML-CL.
				100	99	82	79	44	39	41	17	A-7-6(11)	ML-CL.
				100	95	84	77	18	15	25	2	A-4(8)	ML.
		100	98	93	89	82	79	36	30	39	14	A-6(10)	ML-CL.
				100	94	87	82	40	35	40	11	A-6(9)	ML.
	100	91	89	86	78	58	54	17	13	26	5	A-4(5)	ML-CL.
	100	90	88	86	80	57	49	25	23	32	11	A-6(5)	CL.
92	81	63	51	41	27	20	18	10	8	34	12	A-2-6(0)	GM-GC.
				100	99	85	78	20	15	23	3	A-4(8)	ML.
				100	99	88	83	26	21	28	8	A-4(8)	CL.
				100	99	91	86	47	42	44	17	A-7-6(12)	ML-CL.
				100	99	95	90	18	8	26	5	A-4(8)	ML-CL.
				100	99	96	94	28	18	30	8	A-4(8)	ML-CL.
96	92	81	72	67	64	62	59	20	15	32	11	A-6(6)	CL.

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TABLE 6.—*Engineering test data for soil samples*

Soil name and location	Parent material	Oklahoma report number	Depth	Horizon	Shrinkage		Volumetric change from field moisture equivalent
					Limit	Ratio	
Osage silty clay: 300 feet W. of E. ¼ of sec. 7, T. 28 N., R. 22 E. (Modal profile.)	Alluvium from prairie soils derived from shale and limestone.	SO-3465	0-10	A_1	16	1.84	51
		SO-3466	10-16	AC	21	1.67	35
		SO-3467	16-42+	C	13	1.95	55
Parsons silt loam, 0 to 1 percent slopes: 1,000 feet W. of house in SE¼ of sec. 25, T. 27 N., E. 22 R. (Modal profile.)	Shale	SO-3453	0-6	A_{1p}	27	1.53	4
		SO-3454	15-30	B_{21}	11	1.97	72
		SO-3455	38-46+	C	12	1.98	53

[1] Tests performed by Oklahoma Department of Highways in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Mechanical analyses according to the AASHO Designation T 88. Results by this procedure frequently differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the

In the Unified system, soils are identified on the basis of texture and plasticity and on their performance as material for engineering construction. The soil materials are identified as coarse grained, which are gravels (G) and sands (S); fine grained, which are silts (M) and clays (C); and highly organic (Pt). In this system clean sands are identified by the symbols SW or SP; sands with fines of silt and clay are identified by the symbols SM and SC; silts and clays that have a low liquid limit are identified by the symbols ML and CL; and silts and clays that have a high liquid limit are identified by the symbols MH and CH.

The AASHO system classifies the soils according to their engineering properties based on field performance of highways. In this system soil materials are classified in seven basic groups, designated as A-1 through A-7. The best soils for road subgrades—gravelly soils of high bearing capacity—are classified as A-1; the next best, A-2; and so on to the poorest, which are classified as A-7. Within each group, the relative engineering value of the soil material is indicated by a group index number. The range for the group index number is from 0 for the best material to 20 for the poorest. The group index is shown in parentheses after the soil group symbol in table 6.

In table 4 in the column showing permeability, the rate at which water moves downward in undisturbed soil is estimated. The permeability of the soil was estimated as it occurs in place, and the estimates were based on soil structure and porosity. The rating is expressed in inches per hour and is often referred to as the intake rate. Not considered in the estimates are surface crusting, plowpans, and other features caused by mechanical means.

Available water capacity, reported in inches per inch of soil depth, refers to the approximate amount of capillary water in the soil when the soil is wet to field capacity. When the soil is air dry, the amount of water indicated will wet the soil material described to a depth of 1 inch without deeper percolation.

The column showing reaction indicates the estimated acidity or alkalinity of the soils and is expressed in pH. A pH of 4.5 to 5.0 indicates a very strongly acid soil, and a pH of 9.1 or higher indicates a very strongly alkaline soil.

The shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. It is based on volume-change tests or observance of other physical properties or characteristics of the soil. In table 4 shrink-swell potential is expressed as high, medium, and low. For example, the soil material from the A horizon of Osage silty clay is very sticky when wet and develops extensive shrinkage cracks when dry. Thus, it has high shrink-swell potential. Baxter silt loam, on the other hand, contains much less clay and has low plasticity. Therefore, it has low shrink-swell potential.

The hydrologic soil group is a rating of the entire soil profile to the depth shown in the column "Depth from surface." Four hydrologic soil groups have been defined. Soils are grouped on their ability to absorb water at the end of a storm of long duration which occurs after prior wetting, and after the opportunity for swelling, and without the protective effects of vegetation. Hydrologic group A consists mostly of sandy soils that have the lowest runoff potential; group D consists mostly of clays that have the highest runoff potential.

Table 5 shows specific features of the soils that affect their use for engineering. These features may affect the selection of a site, and they may affect the design of a structure or the application of measures to make the soils suitable for construction. The data in this table are based on estimated data given in table 4, on actual test

taken from seven soil profiles in Ottawa County, Okla.[1]—Continued

Mechanical analysis[2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—							Percentage smaller than—					AASHO[3]	Unified[4]
1 in.	¾ in.	⅜ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
-------	-------	-------	-------	-------	100	99	95	54	41	54	22	A-7-5(16)	MH.
-------	-------	-------	-------	-------	100	98	95	46	38	46	13	A-7-5(10)	ML.
-------	-------	-------	-------	-------	100	98	95	46	40	55	29	A-7-5(19)	CH.
-------	-------	-------	-------	100	99	88	83	20	11	32	6	A-4(8)	ML.
-------	-------	-------	-------	100	99	95	93	56	50	62	28	A-7-5(20)	MH.
-------	-------	-------	-------	100	98	90	86	57	40	50	26	A-7-6(16)	CL.

material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 8): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. AASHO Designation: M 145-49.

[4] Based on the Unified Soil Classification System, Tech. Memo. No. 3-357, v. 1. Waterways Expt. Sta. Corps of Engin. March 1953.

[5] One-hundred percent of the material passes the 1½-inch sieve.

data given in table 6, on field experience, and on the observed performance of the soils. The practices listed in table 5 are those common to the county. Suitability ratings as a source of material for various uses are given as well as undesirable features, but desirable features are also listed.

Normally only the surface layer of a soil is rated for topsoil, since the suitability of a soil for topsoil material depends largely upon the texture and depth of the surface layer. Topsoil material must be capable of being worked into a good seedbed for seeding or sodding, yet be clayey enough to resist erosion when used on steep slopes. The depth of suitable material determines whether or not it is economical or wise to remove the material for use as topsoil.

All or a part of the entire profile is evaluated as a source of gravel. Soil material that is suitable as a source of gravel has a high percentage of gravel. The material can be used as it comes from the pit or it may be washed and graded. The rating as a suitable source of gravel is based on the quality and quantity of the material.

The suitability of the soils for select grading material depends primarily upon the size of the particles and the kind of binding material that holds the particles together. If a binder is added for cohesion, soils that are primarily sands are rated as a good source of grading material. Clay soils compress under load but rebound when unloaded; thus, they are rated poor as a source of grading material.

Every kind of soil material is used in a road fill. Some soils, such as sandy clays and sandy clay loams, offer few problems in placement on compaction. Clays with a high shrink-swell potential require special compaction techniques and close moisture control during and after construction. Sands compact well but are difficult to confine if used in a fill. The ratings in table 5 reflect the ease with which these problems can be overcome.

In table 6 a summary of the test data made on typical profiles of the county is given. Only selected soils were collected and sampled. Test data for other soils are given in other published soil survey reports. The data furnished in this table are the results of tests made by the State of Oklahoma Department of Highways, Materials and Research Department, in accordance with standard procedures of the Association of State Highway Officials.

The tests for liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content, on a dry basis, at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

As moisture leaves a soil, the soil shrinks and decreases in volume in proportion to the loss in moisture until a point is reached where shrinkage stops, although additional moisture is removed. The moisture content where shrinkage stops is called the shrinkage limit of the soil and is reported as the moisture content in relation to the ovendry weight of the soil at the time when shrinkage stops.

Since clay is the major soil fraction that causes shrinkage, the shrinkage limit of a soil is a general index of the content of clay and will, in general, be a low number for soils that contain a great deal of clay. The shrinkage

limit of a sand that contains little or no clay, however, is close to the liquid limit and is considered insignificant. The shrinkage limit of sands that contain some silt and clay ranges from about 14 to 25, and the shrinkage limit of clays ranges from about 9 to 14. As a rule, the load-carrying capacity of a soil is at a maximum when its moisture content is at or below the shrinkage limit. Sands do not follow this rule because they have a uniform load-carrying capacity within a wide range of moisture content, providing they are confined.

The shrinkage ratio of a soil is the volume change resulting from the drying of the soil material, divided by the loss of moisture caused by drying. Theoretically, it is also the apparent specific gravity of the dried soil pat.

Volume change from field moisture equivalent (FME) is defined as the volume change, expressed as a percentage of the dry volume of the soil mass, when the moisture content is reduced from the FME to the shrinkage limit. The FME is the minimum content of moisture at which a smooth surface of an undisturbed soil will absorb no more water in 30 seconds when the water is added in individual drops. It is the moisture content required to fill all the pores in sands and to approach saturation in cohesive soils that have not been disturbed.

The engineering soil classifications given in table 6 were based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. Mechanical analyses was made by the combined sieve and hydrometer methods. Percentages of clay obtained in this test by the hydrometer are not suitable for determining U.S. Department of Agriculture textural classes of soils.

Descriptions of the Soils

The farmers and ranchers in Ottawa County have learned many facts about their soils through experience. They know the places that drain slowly, the fields where the soils erode severely, the gravelly or stony places, and the soils that are droughty. This part of the soil survey report describes the soils in Ottawa County and can help each operator understand his soils better. Suggestions about how the soils can be managed to control erosion and to keep the soils productive are given in the section "Use and Management of the Soils."

The soil series and mapping units are described briefly in this section. The generalized profile described for each series is considered representative for all the mapping units of that series. Any differences from the representative profile are evident in the name of each mapping unit or are pointed out in its description.

A soil symbol in parentheses follows each mapping unit and identifies that unit on the detailed soil map. Listed at the end of the description of a mapping unit are the capability unit and range site in which that kind of soil has been placed. The pages on which the capability unit and range site are described can be found readily by referring to the "Guide to Mapping Units, Capability Units, and Range Sites" at the back of this report.

The approximate acreage and proportionate extent of each soil are given in table 7. Terms used in describing the soils are defined in the Glossary. A discussion of how the soils are formed and classified is given in the section "Formation, Classification, and Morphology of Soils."

TABLE 7.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
	Acres	*Percent*
Alluvial land	5, 556	1. 8
Bates loam, 1 to 3 percent slopes	1, 824	. 6
Bates loam, 3 to 5 percent slopes	3, 525	1. 1
Bates loam, 2 to 5 percent slopes, eroded	955	. 3
Bates loam, shallow	1, 887	. 6
Baxter silt loam, 1 to 3 percent slopes	2, 480	. 8
Baxter silt loam, 3 to 5 percent slopes	352	. 1
Bodine cherty silt loam, 0 to 3 percent slopes	5, 601	1. 8
Bodine very cherty silt loam, 1 to 8 percent slopes	33, 235	10. 8
Bodine stony silt loam, steep	38, 762	12. 5
Breaks-Alluvial land complex	3, 212	1. 0
Choteau silt loam, 0 to 1 percent slopes	3, 447	1. 1
Choteau silt loam, 1 to 3 percent slopes	4, 071	1. 3
Collinsville soils	2, 557	. 8
Craig silt loam, 1 to 3 percent slopes	5, 647	1. 8
Craig silt loam, 3 to 5 percent slopes	2, 527	. 8
Dennis silt loam, 0 to 1 percent slopes	1, 266	. 4
Dennis silt loam, 1 to 3 percent slopes	40, 697	13. 2
Dennis silt loam, 3 to 5 percent slopes	592	. 2
Dennis silt loam, 2 to 5 percent slopes, eroded	1, 153	. 4
Eldorado soils	4, 735	1. 5
Etowah silt loam, 0 to 3 percent slopes	4, 464	1. 4
Etowah gravelly silt loam, 3 to 8 percent slopes	1, 822	. 6
Huntington gravelly silt loam	2, 050	. 7
Huntington silt loam	6, 365	2. 1
Kaw silty clay loam	1, 049	. 3
Lawrence silt loam	1, 479	. 5
Lightning silt loam	1, 296	. 4
Mine pits and dumps	5, 268	1. 7
Newtonia silt loam, 1 to 3 percent slopes	3, 990	1. 3
Newtonia silt loam, 3 to 5 percent slopes	753	. 2
Newtonia silt loam, 2 to 5 percent slopes, eroded	807	. 3
Newtonia-Sogn complex	668	. 2
Osage silty clay	11, 445	3. 7
Parsons silt loam, 0 to 1 percent slopes	22, 746	7. 4
Parsons silt loam, 1 to 3 percent slopes	10, 187	3. 3
Parsons silt loam, 1 to 3 percent slopes eroded	825	. 3
Riverton gravelly loam, 3 to 5 percent slopes	1, 174	. 4
Summit silty clay loam, 1 to 3 percent slopes	1, 608	. 5
Taloka silt loam, 0 to 1 percent slopes	38, 276	12. 4
Verdigris silt loam	7, 679	2. 5
Woodson silty clay loam, 0 to 1 percent slopes	6, 035	2. 0
Woodson silty clay loam, 1 to 3 percent slopes	1, 690	. 6
Land areas	295, 757	95. 7
Lakes and rivers	13, 363	4. 3
Total	309, 120	100. 0

Following that section is a detailed description of each soil series in the county.

Alluvial Land (Ad)

This miscellaneous land type is made up of nonarable areas of alluvial soils. Along the Neosha River and its tributaries it consists of Osage and Verdigris soils, and along the Spring River and its tributaries, of Huntington soils. The narrow bands of this land are flooded several times each year. Some are cut by meandering streams. The Huntington soils are mostly gravel because water has removed the soil material. The named soils making up this land type are described under their respective series.

Most of this land is covered with pin oak, pecan, elm, and other lowland hardwoods. It is pastured and is not suitable for crops. Generally, it is productive, but it is flooded too frequently for economical production of crops. (Capability unit Vw-1; not assigned to a range site)

Bates Series

In the Bates series are moderately deep, well-drained, gently sloping or moderately sloping soils. These soils are scattered throughout the prairies in the western two-thirds of the county. They formed under tall grasses in material from noncalcareous sandstone and interbedded shale.

The surface layer is grayish-brown or dark grayish-brown, granular loam that is 10 to 16 inches thick. The subsoil, about 16 inches thick, is finely mottled, yellowish-brown or reddish-brown, granular light clay loam or sandy clay loam. The upper part of the subsoil is darker colored than the lower part and contains some organic matter. Weathered sandstone is at a depth of about 30 inches. In places the soil layers are thinner than described and the sandstone is at a depth of about 17 inches.

Bates soils are near the Dennis, Parsons, and Collinsville soils. Mapping units of the Bates soils include small areas of Dennis and Collinsville soils. These included soils are too small to be mapped separately.

Bates soils are slightly acid to medium acid. They have a good supply of organic matter and are in good tilth. Since their natural fertility is only fair, a fertilizer high in nitrogen and phosphate is needed for improved yields.

These soils are subject to erosion, and erosion is likely to be serious on the moderately sloping soils. In cultivated areas a plowpan is common.

Bates loam, 1 to 3 percent slopes (BaB).—The surface layer of this gently sloping soil is about 14 inches thick.

This soil is well suited to cultivation. Wheat, oats, corn, soybeans, and grain sorghum are the principal crops. Alfalfa can be grown if sufficient lime and phosphate are applied. Yields of all crops are moderate to good, but are lower than on the productive soils of the bottomlands that provide more moisture.

This soil is likely to erode if it is cultivated and not protected. Returning large amounts of crop residues or other vegetation to the soil helps to maintain organic matter and the structure of the soil.

On this soil, range or native meadow in good condition is dominantly bluestem, switchgrass, and Indiangrass. In areas overgrazed, these are replaced by poor perennial grasses, annual grasses, and weeds. (Capability unit IIe-2; Loamy Prairie range site)

Bates loam, 3 to 5 percent slopes (BaC).—The surface layer of this moderately sloping soil is about 13 inches thick.

This soil is suited to cultivation. Wheat, oats, corn, grain sorghum, and soybeans are the principal crops. Alfalfa is poorly suited because much rain that falls is lost through runoff and little moisture is available for the crops. About half of the acreage is used for range or native hay.

The hazard of erosion is serious, and intensive practices are required to control erosion if the soil is cultivated. Returning crop residues to the soil and growing green-manure crops help to maintain the content of organic matter and the structure of the soil. (Capability unit IIIe-1; Loamy Prairie range site)

Bates loam, 2 to 5 percent slopes, eroded (BaC2).—About 75 percent of this gently sloping to moderately sloping soil has a slope of 3 to 5 percent. The surface layer ranges from 0 to 12 inches in thickness but is generally about 6 inches thick. Erosion has caused rills and removed material from the surface layer. Lighter colored spots show where the surface layer is thin. In these, plowing has mixed material of the remaining surface layer with the upper part of the subsoil.

About half the acreage of this soil is cultivated. Wheat, oats, and grain sorghum are the principal crops. Because the surface layer is thinner, this soil is more susceptible to erosion than the other Bates soils. Consequently, intensive practices are needed to protect this soil and to control further erosion.

Practices that help control erosion are terracing, contour farming, and keeping a protective cover on the soil as much of the time as feasible. The supply of organic matter can be maintained or increased by turning under crop residues or by growing green-manure crops. These practices also improve tilth of the surface layer, increase the intake of water, and increase yields. Yields are also increased in most years if fertilizer is applied. (Capability unit IIIe-3; Loamy Prairie range site)

Bates loam, shallow (Bb).—This soil is thinner than the other Bates soils. The surface layer is about 10 inches thick, but depth to sandstone averages only about 17 inches. Slopes range from 1 to 5 percent.

Because this soil has less depth, it stores less moisture than other Bates soils and has a lower supply of plant nutrients. It is therefore more droughty and needs more fertilizer if it is cultivated. The hazard of erosion is severe.

Most of this soil is in native grass used for range or hay. Small areas are cultivated along with surrounding soils. The soil can be cultivated occasionally but is best used for grass. If the soil is cultivated, terracing, contour farming, growing of cover crops, and similar intensive management are needed. Fertility can be maintained and tilth improved by returning crop residues to the soil and growing green-manure crops. (Capability unit IVe-3; Loamy Prairie range site)

Baxter Series

The Baxter series is made up of deep, well-drained, silty soils that have varying amounts of chert fragments in the surface layer and subsoil. These soils are on smooth ridgetops in wooded upland areas, mostly east of the Spring River. They formed in material from cherty limestone.

The surface layer is thin and silty, and the subsurface layer is thick, light colored, and silty. Below is a yellowish-red or red subsoil. The amount of chert is small in the upper layers of the profile but increases in the subsoil.

Baxter soils are near the Bodine and Lawrence soils. They are less droughty than the Bodine soils and are less cherty in the upper soil layers. They are better drained than the Lawrence soils and have a redder subsoil.

The Baxter soils are strongly acid to very strongly acid. Their content of organic matter is low, and their fertility is low or medium. These soils are easily tilled. Permea-

bility, or movement of water and air through the soils, is slow or moderately slow.

If these soils are well managed, pine and hardwood trees can be grown on them.

Baxter silt loam, 1 to 3 percent slopes (BcB).—The surface layer of this gently sloping soil is about 3 inches thick in undisturbed areas. The light-colored subsurface layer is about 12 inches thick, and the subsoil is blocky, clayey material that is yellowish red or red.

Most of this soil is cultivated. Wheat, oats, corn, grain sorghum, and tame pasture are the principal crops.

This soil is susceptible to erosion. Therefore terracing, contour farming, and other practices are needed to control erosion and maintain fertility and organic matter. Returning crop residues to the soil and growing green-manure crops improve tilth of the surface layer, increase the intake of water, and increase yields. Yields are also increased if lime and fertilizer are applied in the amounts indicated by soil tests and according to the needs of the crops. (Capability unit IIe–2; Smooth Chert Savannah range site)

Baxter silt loam, 3 to 5 percent slopes (BcC).—The combined thickness of the surface and subsurface layers is slightly less in this moderately sloping soil than in Baxter silt loam, 1 to 3 percent slopes, and susceptibility to erosion is greater.

About 60 percent of the acreage of this soil is used for wheat, oats, grain sorghum, and tame pasture. Terracing, contour farming, adding barnyard manure, returning crop residues to the soil, growing green-manure crops, and similar intensive management are needed. These practices help to control erosion and to maintain organic matter and fertility. Yields are increased in most years if fertilizer is applied. (Capability unit IIIe–1; Smooth Chert Savannah range site)

Bodine Series

In the Bodine series are deep, well-drained to somewhat excessively drained, gently sloping to steep soils of the uplands. These soils are on smooth ridgetops and steep breaks in the eastern part of the county, mostly east of the Spring River. They formed mainly under forest, but partly under tall grass, in material weathered from cherty limestone.

These soils have a thin, organic-mineral surface layer and a thick, light-colored subsurface layer. The subsoil is light brown to reddish yellow and contains only a small amount of fine material.

Bodine soils are near the Baxter and Lawrence soils. They are more cherty or stony than either of those soils and are less clayey in the subsoil. They are also more droughty.

The Bodine soils are strongly acid to very strongly acid and are low in organic matter and fertility. Large amounts of chert and stone in the soils make tillage difficult. These soils take in large quantities of water, but they do not store it for plant use.

These soils are the most extensive in the county. Overgrazing, burning, and improper cutting have removed most of the harvestable trees from areas that formerly were wooded, and only a brushy growth remains. If pine and hardwood trees are established on these soils and properly managed, they grow well.

Bodine cherty silt loam, 0 to 3 percent slopes (BdB).—This soil is deep, well drained, and nearly level to gently sloping. The surface layer is grayish-brown cherty silt loam about 3 inches thick. It is underlain by light-colored cherty silt loam that is about 18 inches thick. The subsoil is yellowish-red or red very cherty silty clay loam that is mottled with brownish yellow and white in the lower part.

About 50 percent of the acreage of this soil is still in trees and is used for grazing. The rest is in small grain, grain sorghum, and tame pasture.

This soil is droughty and low in fertility. Improvement in supply of organic matter, tilth of the surface layer, intake of water, and yield can be achieved by adding barnyard manure, turning under crop residues, and growing green-manure crops. Yields are also increased in most years if fertilizer is applied. (Capability unit IVs–1; Smooth Chert Savannah range site)

Bodine very cherty silt loam, 1 to 8 percent slopes (BnD) —This soil is deep, well drained, gently sloping to strongly sloping, and cherty (fig. 14). Internal drainage is rapid, and the soil is droughty.

This soil is rapidly permeable. It takes in large quantities of water, but it has little moisture-storage capacity. There is little runoff, and the hazard of erosion is not serious.

Much of this soil is in trees and is pastured. The cleared areas are used mostly for tame pastures made up largely of annual lespedeza. In many places additional grazing is provided by establishing bermudagrass and overseeding with legumes.

This soil is better suited to grass or trees than to cultivated crops. If necessary, it occasionally can be used for crops grown in rotation with perennial grasses or legumes. If this soil is used for crops, the fertility and organic matter must be maintained at as high a level as practical for economical yields. Growing grasses or leg-

***Figure 14.*—Strawberries on Bodine very cherty silt loam, 1 to 8 percent slopes. This soil has a large amount of chert on the surface.**

umes 3 years out of 4 helps maintain the content of organic matter. (Capability unit IVs-1; Smooth Chert Savannah range site)

Bodine stony silt loam, steep (BoE).—This soil is deep and has many chert stones throughout the profile and on the surface. It takes in large quantities of water, but it is droughty and has little moisture-storage capacity. Slopes range from 12 to 50 percent.

Most of this soil is wooded and is used largely for grazing. Small areas have been cleared and farmed along with adjacent areas. Most of them have been abandoned and are now covered with brush and weeds.

Steep slopes and stones make this soil poorly suited to cultivation. Grazing must be controlled, since the grass is killed on heavily grazed areas and brush then encroaches. (Capability unit VIIs-1; Steep Chert Savannah range site)

Breaks-Alluvial Land Complex (Br)

This soil complex consists of areas of Breaks and of Alluvial land that are too small and intermingled to be mapped separately. It occurs throughout upland areas on the prairies in V-shaped, entrenched drainageways. These drainageways are 100 to 200 feet wide. Steep upland soils are on the side slopes of the drainageways, and alluvial soils are on the bottoms. The soils on the side slopes, which make up about 60 percent of the complex, are of the Bates, Dennis, Parsons, and Taloka series. The soils on the narrow strips of bottom lands along the drainageways are of the Verdigris and Kaw series. Each of the soils in this complex is described under its respective series.

The soils in this complex are excessively drained. Their water-holding capacity is good. Permeability is moderate, slow, or very slow. The content of organic matter and the supply of plant nutrients vary.

Practically all of this complex is in native grass used for range or hay. Yields are good. The hazard of erosion makes this soil poorly suited to cultivation. Furthermore, unless a good cover of grass is kept on them, areas in native grass are likely to erode. (Capability unit VIe-1; Loamy Prairie range site)

Choteau Series

The soils in the Choteau series are deep and silty and are on uplands. Most of the areas are in the valleys between Miami and Wyandotte. These soils formed under tall prairie grass in old alluvium.

The surface layer is grayish-brown or dark-brown silt loam 10 to 16 inches thick. Below is pale-brown silt loam that is about 10 inches thick. The subsoil is mottled yellowish-brown or brownish-yellow light clay loam or silty clay loam that has blocky structure.

Choteau soils are near the Taloka, Parsons, and Dennis soils. Their subsoil is less clayey than that of the Taloka and Parsons soils. In contrast to the Dennis soils, the Choteau soils have a light-colored subsurface layer and greater depth to their subsoil.

The Choteau soils are strongly acid. They are productive, have a good supply of organic matter, and are generally in good tilth. Fertility is good, but yields are increased if fertilizer is added. These soils take in water slowly and store a large amount of it for plants to use.

Choteau silt loam, 0 to 1 percent slopes (ChA).—The surface layer of this nearly level soil is silty and is about 12 inches thick. Below is a pale-brown, silty layer that is also about 12 inches thick. The subsoil is light clay loam or silty clay loam and is blocky in structure. This soil is slowly drained, but drainage is generally adequate.

Most areas of this soil are cultivated. Wheat is the main crop, but corn, oats, grain sorghum, and soybeans are also grown. Alfalfa can be grown if lime and phosphate are applied.

This soil has no serious limitations. Returning crop residues to the soil, adding barnyard manure, and growing green-manure crops help maintain organic matter and soil structure. Yields are greater in most years if fertilizer is applied. (Capability unit I-2; Loamy Prairie range site)

Choteau silt loam, 1 to 3 percent slopes (ChB).—The surface layer of this gently sloping, well-drained soil is about 10 inches thick.

Most of this soil is cultivated. Wheat is the main crop, but corn, oats, grain sorghum, and soybeans are also grown. Alfalfa can be grown if the acidity of the soil is corrected and a phosphate fertilizer is applied.

This soil erodes if it is cultivated and not protected. In addition, practices are needed that maintain the supply of organic matter and improve the structure of the soil.

Practices that help control erosion are terracing and farming on the contour. Adding barnyard manure, turning under crop residues, and growing green-manure crops are ways of adding organic matter. These practices also improve tilth of the surface layer, increase the intake of water, and increase yields. Yields are also increased in most years if fertilizer is applied. (Capability unit IIe-2; Loamy Prairie range site)

Collinsville Series

In the Collinsville series are very shallow, excessively drained, moderately sloping to steep soils on uplands. These soils occupy small areas on narrow ridges and steep breaks, mainly south and west of Miami. They are forming under tall prairie grass in material weathered from sandstone.

These soils have a surface layer of dark grayish-brown loam that is 2 to 15 inches thick and rests on sandstone. Generally, pieces of sandstone are on the surface.

Collinsville soils are near the Bates and Dennis soils, but they are not so deep as those soils.

The Collinsville soils have a fair supply of organic matter. They lack depth for storage of plant nutrients and moisture.

Collinsville soils (Co).—This is the only unit of Collinsville soils mapped in this county. It is made up of loams and stony loams that are too small and intermingled to be mapped separately. Slopes range from 3 to 20 percent.

These soils are nearly all in grass and are used for hay or for grazing. They are too shallow, stony, and droughty, and in many places too steep, for cultivation. Keeping a good cover of grass on these soils helps to prevent erosion and to maintain high yields. A suitable way to keep a protective cover is to control grazing so that about half of the current growth is left each year. (Capability unit VIIs-2; Shallow Prairie range site)

Craig Series

The Craig series consists of moderately deep, well-drained, gently sloping to moderately sloping, silty soils of the uplands. Most areas of these soils are along the west side of the Spring River and in prairie openings east of that river. These soils formed under tall prairie grass in material weathered from cherty limestone.

The surface layer is grayish-brown or dark-brown silt loam that is 10 to 18 inches thick. The subsoil is finely mottled, brown or reddish-brown silty clay loam or silty clay. Very cherty material is at a depth of 15 to 25 inches.

Craig soils are near the Dennis, Eldorado, and Parsons soils. Unlike the Dennis soils, the Craig soils have chert in the subsoil. They are deeper than the Eldorado soils and are better developed.

The Craig soils are medium acid. They have a high content of organic matter and are in good tilth. Fertility is fair.

Most areas of the Craig soils are cultivated. Wheat, oats, corn, soybeans, and grain sorghum are the principal crops.

Craig silt loam, 1 to 3 percent slopes (CrB).—The surface layer of this gently sloping soil is about 16 inches thick.

Most of this soil is cultivated. Wheat is the principal crop, but oats, corn, grain sorghum, and soybeans are also grown.

This soil erodes if it is cultivated and not protected. The supplies of organic matter and plant nutrients must be kept high and soil structure maintained if this soil is to produce high yields.

Terracing and contour farming help control erosion. Adding barnyard manure, turning under crop residues, and growing green-manure crops are practices that improve the tilth of the surface layer, increase the intake of water, and increase yields. (Capability unit IIe–2; Loamy Prairie range site)

Craig silt loam, 3 to 5 percent slopes (CrC).—The surface layer of this moderately sloping soil is slightly thinner than that of Craig silt loam, 1 to 3 percent slopes.

If protected from erosion, this soil is suited to cultivation. About 50 percent of the acreage is cultivated, and the rest is in native grass used for hay and pasture. The principal cultivated crops are wheat, oats, corn, grain sorghum, and soybeans.

Terracing, contour farming, returning crop residues to the soil, applying barnyard manure, growing green-manure crops, and similar practices are needed. These help to control erosion and to maintain organic matter and fertility.

Yields increase in most years if fertilizer is applied. (Capability unit IIIe–1; Loamy Prairie range site)

Dennis Series

In the Dennis series are deep, generally well-drained soils of the uplands. These soils occur throughout the prairies in the western part of the county. They formed under tall grass in material weathered from sandy and clayey shale.

The surface layer, a grayish-brown or dark grayish-brown silt loam, is 10 to 16 inches thick in uneroded areas. The subsoil is finely mottled, blocky clay loam or clay Its color ranges from brown to yellowish brown.

Dennis soils are near the Bates, Parsons, and Taloka soils. They lack the light-colored subsurface layer of the Parsons and Taloka soils, and their subsoil is less clayey. The Dennis soils are somewhat finer textured throughout the profile than the Bates soils and have somewhat finer textured parent material.

The Dennis soils are strongly acid to very strongly acid. They have a good supply of organic matter and are in good tilth. Natural fertility is also good. These soils take in water slowly and store large quantities of it for plants.

Dennis silt loam, 0 to 1 percent slopes (DnA).—The surface layer of this nearly level soil is about 14 inches thick. Drainage is adequate but is slower than in the more sloping Dennis soils.

Most of this productive soil is cultivated. Wheat is the principal crop, but corn, oats, grain sorghum, and soybeans are also grown. Alfalfa can be grown successfully if sufficient lime and phosphate are applied. Yields can be increased if fertilizer and lime are applied in amounts indicated by soil tests and the needs of the crop.

There are no serious problems in managing this soil; it can be kept productive if good farming methods are used. Adding barnyard manure, returning crop residues to the soil, and growing green-manure crops are practices that add organic matter, improve tilth of the surface layer, increase intake of water, and increase yields. Yields also increase in most years if fertilizer is applied. (Capability unit I–2; Loamy Prairie range site)

Dennis silt loam, 1 to 3 percent slopes (DnB).—The surface layer of this gently sloping soil is about 12 inches thick.

Most areas of this soil are cultivated. The principal crop is wheat, but corn, oats, grain sorghum, and soybeans are also grown.

This soil erodes if it is cultivated and not protected. Therefore, practices are needed that control erosion, maintain fertility and organic matter, and build up the structure of the soil.

Terracing and farming on the contour help to control runoff and, thus, to control erosion. Applying barnyard manure, returning crop residues to the soil, and growing green-manure crops are practices that add organic matter, improve tilth, increase intake of water, and increase yields. Generally yields also increase if fertilizer is added. (Capability unit IIe-2; Loamy Prairie range site)

Dennis silt loam, 3 to 5 percent slopes (DnC).—The surface layer of this moderately sloping soil is about 11 inches thick.

About one-half of the acreage of this soil is cultivated. Wheat, oats, and grain sorghum are the crops most commonly grown. Native grass, used for pasture or hay, is on most of the soil that is not cultivated.

This soil is subject to serious erosion. Therefore, practices that help to control erosion and to maintain organic matter and fertility are needed. Terracing, contour farming, returning crop residues to the soil, adding barnyard manure, growing green-manure crops, and other intensive practices should be used. A grass or legume crop is needed in the cropping system at least one-third of the time. (Capability unit IIIe–1; Loamy Prairie range site)

Dennis silt loam, 2 to 5 percent slopes, eroded (DnC2).—The surface layer of this moderately eroded soil is about 6 inches thick. In plowed areas erosion has caused rills and removed material from the surface layer. Lighter colored spots show where the surface layer is thin. In these, plowing has mixed the remaining surface layer with the upper part of the subsoil.

Nearly all of this soil has been cultivated, but now a large part is idle or in grass used for pasture. In some places wheat, oats, and grain sorghum are grown, but yields are lower than on Dennis soils that are not eroded.

This soil is more susceptible to erosion than Dennis silt loam, 3 to 5 percent slopes, since its surface layer is thinner. The supplies of organic matter and plant nutrients are low.

Maintaining organic matter and controlling erosion are necessary practices. Desirable practices are terracing, contour farming, returning crop residues to the soil, and growing green-manure crops. A grass or a legume is needed in the cropping system at least one-third of the time. (Capability unit IIIe-3; Loamy Prairie range site)

Eldorado Series

In the Eldorado series are well-drained to somewhat excessively drained, gently sloping to strongly sloping soils of the uplands. These soils occupy small areas, mainly breaks and narrow ridges, in a strip that runs north and south through the county near the west side of the Spring River; other small areas are in prairie openings east of that river. The Eldorado soils formed under tall prairie grass in material weathered from cherty limestone.

The surface layer is dark grayish-brown or black silt loam or stony silt loam. It ranges from 2 to 14 inches in thickness but averages about 8 inches. The subsoil is pale-brown very cherty light clay loam to very cherty heavy silty clay loam that is about 75 percent chert. Depth to parent material is about 14 inches. There are many stones on the surface.

Eldorado soils are near the Craig and Dennis soils. They are shallower than the Craig soils and are less well developed.

The Eldorado soils have a strongly acid subsoil. They have a good supply of organic matter and are low to medium in fertility. Permeability is rapid. Stones make these soils difficult to cultivate.

Only a few small areas of these soils have been cultivated; the rest remains in native grass. As the result of overgrazing, desirable grasses have been replaced in many pastures by annual grasses and weeds and by sumac, persimmon sprouts, and other bushes and scrubby trees.

Eldorado soils (Ed).—This is the only soil of the Eldorado series mapped in this county. It is made up of silt loams and stony silt loams that are too small and intermingled to be mapped separately. Slopes range from 1 to 8 percent.

These soils are nearly all in native grass used for range or hay. They are too rocky and droughty for cultivation. Only small areas that are farmed along with other soils are cultivated. Yields of pasture or hay are fair if these soils are managed properly. In overgrazed pastures, the tall prairie grasses are replaced by weeds and sprouts. These weedy and brushy pastures generally need reseeding to tall prairie grasses. (Capability unit VIs-1; Loamy Prairie range site)

Etowah Series

Soils of the Etowah series are deep, well drained, and nearly level to strongly sloping. They are on narrow benches along the Spring River and its tributaries. They formed in alluvium under scattered hardwood trees and tall grasses on benches that lie 10 to 20 feet above the flood plain.

The surface layer is brown silt loam that is about 9 to 16 inches thick. The subsoil is yellowish-red, reddish-brown, or brown light silty clay loam or gravelly clay loam. Gravel beds are at a depth between 30 and 48 inches.

These soils generally occupy areas between steep Bodine soils on uplands and Huntington soils on flood plains. They are redder than the Huntington soils and occur above the flood plains. Unlike the Bodine soils, which are cherty or stony, Etowah soils are gravelly.

Etowah soils are strongly acid to very strongly acid in the surface layer and slightly acid to strongly acid in the subsoil. They have a good supply of organic matter and plant nutrients. Permeability is moderate. Except where they are gravelly, these soils are easily tilled.

The Etowah soils are productive and are well suited to cultivation. The principal crop is corn, but wheat, oats, grain sorghum, and soybeans are also grown. Alfalfa can be grown if lime and phosphate are applied. Trees grown for posts produce well on these soils.

Etowah silt loam, 0 to 3 percent slopes (EtA).—The surface layer of this nearly level to gently sloping soil is about 14 inches thick and in many places contains a small amount of rounded chert gravel.

Mapped with this soil are areas of Etowah gravelly silt loam, 3 to 8 percent slopes, and of Huntington soils. These included soils are too small to be mapped separately.

Etowah silt loam, 0 to 3 percent slopes, is moderately productive, and most of it is cultivated. Alfalfa can be grown. Bermudagrass, yellow hop clover, and other tame pasture crops produce good yields. Once they are established, hardwoods and pines grow well if they are well managed.

Little erosion occurs on the nearly level areas of this soil, but the more sloping areas erode unless they are protected. The irregular slopes make terracing difficult. Therefore, a cover should be kept on the soil as much of the time as feasible and crop residues should be returned to the soil. Growing legumes and grasses in the cropping system helps to maintain organic matter and soil structure and to reduce runoff. Lime is needed for some plants. Yields are generally increased if fertilizer is applied. (Capability unit IIe-2; Smooth Chert Savannah range site)

Etowah gravelly silt loam, 3 to 8 percent slopes (EhD).—The surface layer of this moderately sloping to strongly sloping soil is about 10 inches thick. Chert fragments from sloping Bodine soils have accumulated on the surface.

Mapped with this soil are areas of Etowah silt loam, 0 to 3 percent slopes, and of Bodine soils. These included soils are too small to be mapped separately.

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Etowah gravelly silt loam, 3 to 8 percent slopes, is best kept in grass or trees. Tame pasture crops grow well. Once they are established, hardwoods and pines also grow well if they are well managed.

This soil is somewhat droughty and is subject to erosion. Therefore, practices that control erosion and maintain organic matter and fertility are needed.

On this soil, terraces are difficult to maintain because of runoff from steep Bodine soils. Chert fragments accumulate in the channels of the terraces, block them, and cause the terraces to break. Therefore, it is best to keep bermudagrass or other cover on the soil at least 3 out of 4 years to control erosion. Yields increase if fertilizer is applied. (Capability unit IVe-2; Smooth Chert Savannah range site)

Huntington Series

The Huntington series consists of deep, well-drained, nearly level soils. These soils are on flood plains along the Spring River and its tributaries. They are forming in alluvium from cherty soils. The natural vegetation is lowland hardwoods.

The surface layer, a grayish-brown or dark grayish-brown silt loam or gravelly silt loam, is 10 to 12 inches thick. The subsoil is brown to dark grayish-brown gravelly or very gravelly clay loam or silty clay loam. Gravel makes up 40 to 80 percent of the subsoil.

Huntington soils are near the Etowah and Bodine soils. Their subsoil is less red than that in the Etowah soils, and they are forming in recent alluvium rather than in old alluvium.

The Huntington soils are medium acid. They have a good supply of organic matter and a moderate to good supply of plant nutrients. Permeability is moderate.

The Huntington silt loams are easily tilled, but tillage is more difficult in the gravelly silt loams. Hardwood trees grow well on the Huntington soils.

Huntington gravelly silt loam (Hg).—The surface layer of this soil contains 10 percent or more of gravel. This soil is mostly along the smaller streams. Natural fertility is lower than in the other Huntington soils.

Mapped with this soil are areas of Huntington silt loam and of Etowah silt loam, 0 to 3 percent slopes. These included soils are too small to be mapped separately.

Huntington gravelly silt loam is suited to cultivation, but the choice of crops is restricted because floods generally occur two or three times each year. Most of the larger areas are cultivated. The main crops are annual lespedeza, fescue, bermudagrass, yellow hop clover, and other tame pasture crops. Hardwood trees can be grown successfully. (Capability unit IIw-1; not assigned to a range site)

Huntington silt loam (Hu).—This soil has a silty surface layer and a gravelly subsoil (fig. 15). The areas are nearly level and are mostly along the larger streams in the eastern part of the county.

Included with this soil in mapping are small areas of Huntington gravelly silt loam, and of Etowah silt loam, 0 to 3 percent slopes.

Huntington silt loam is productive and well suited to cultivation. It is flooded occasionally, but the floods seldom damage the soil. Generally, they deposit silt on the soil instead of eroding it. Corn is the principal crop, but wheat, oats, soybeans, and grain sorghum are also grown. Alfalfa can be grown if lime and phosphate are applied. Flooding, however, sometimes ruins one cutting of alfalfa. On this soil, hardwood trees grown for posts produce well.

Figure 15.—Profile of Huntington silt loam showing the silty surface soil and the gravelly subsoil.

Except for occasional flooding, this soil has no serious limitations. Returning all crop residues to the soil and growing green-manure crops once in 5 years helps maintain organic matter and soil structure. Yields increase in most years if fertilizer is applied. (Capability unit I-1; not assigned to a range site)

Kaw Series

In the Kaw series are deep, well drained or moderately well drained, nearly level soils. These soils are on flood plains along some of the smaller streams east of Miami. They are forming under tall prairie grasses and scattered trees in alluvium washed from soils of the prairies.

The surface layer is dark-gray clay loam about 29 inches thick. The subsoil, a dark grayish-brown clay loam or silty clay, is faintly mottled.

Kaw soils are mostly near the Bates, Dennis, Woodson, and Verdigris soils. They are similar to the Verdigris soils, but they have a darker surface layer. They are less clayey and better drained than the Woodson soils, which are on the uplands.

The Kaw soils are slightly acid to medium acid. They have a good supply of organic matter and of plant nutri-

ents. These soils are in good tilth. They absorb water slowly and store large quantities of it for plants to use.

The acreage of these soils is small, and the areas are flooded occasionally. Most areas are cultivated. Corn, wheat, oats, grain sorghum, and soybeans are the principal crops.

Kaw silty clay loam (Ka).—This is the only soil of the Kaw series in this county. It is flooded about once each year, but damage to crops seldom result because the floodwaters generally recede within a few hours after a rain.

This is one of the most productive soils in the county. It is well suited to cultivation, and most of it is cultivated. Corn is the principal crop, but wheat, oats, soybeans, and grain sorghum are also grown. Alfalfa can be grown if lime and phosphate are applied.

This soil has no serious limitations. Returning crop residues to the soil, growing green-manure crops, and other good farming methods are the practices needed. These practices help improve tilth of the surface layer, increase intake of water, and increase yields. (Capability unit I–1; Loamy Bottomland range site)

Lawrence Series

The soils in the Lawrence series are deep, somewhat poorly drained, and nearly level. They are on smooth ridgetops east of the Spring River. They formed in material weathered from cherty limestone. Their native vegetation was hardwood trees, mostly oaks.

The surface layer is thin silt loam, about 4 inches thick, that overlies a thick, very pale brown silty layer. The subsoil is yellowish-brown to grayish-brown, mottled, blocky silty clay loam; in it water percolates very slowly.

Lawrence soils are near the Baxter and Bodine soils. They are less red, more nearly level, and less well drained than the Baxter soils.

In the Lawrence soils, the subsoil is very strongly acid. The supplies of organic matter and plant nutrients are poor. Permeability is very slow. During seasons of heavy rainfall, these soils are hard to till.

About half of the acreage of these soils is cultivated. The rest is still wooded and is used for pasture. Wheat, oats, grain sorghum, and tame pasture plants are the main crops.

Lawrence silt loam (La).—This is the only soil of the Lawrence series mapped in this county. The areas are small and are on flats.

Included with this soil are areas of Baxter soils that are too small to be mapped separately.

Lawrence silt loam is suited to cultivation, and about half of the acreage is cultivated. Wheat, oats, grain sorghum, and tame pasture plants are the main crops.

This soil is not susceptible to erosion, but it remains wet for several days after a rain and is droughty in dry seasons. The almost impervious, clayey subsoil restricts movement of air and water. If the soil is in good tilth, the first inch of rain penetrates the soil readily and soaks the layers above the clayey subsoil. Water then penetrates very slowly. The subsoil stores much moisture, but it releases it to plants slowly. Therefore, returning crop residues to the soil, growing green-manure crops, and similar practices are needed. These practices add organic matter and increase the intake of water.

Hardwood trees grow well on this soil if they are properly managed. Burning, overgrazing, and indiscriminate cutting have removed most of the harvestable trees and left a bushy growth. (Capability unit IIs–1; not assigned to a range site)

Lightning Series

In the Lightning series are deep, somewhat poorly drained, nearly level soils. These soils are on flood plains of the Neosho River and its tributaries, mostly on flood plains of the smaller tributaries. They are forming in alluvium washed from soils of the prairies. The native vegetation was mainly tall grass that required much water, but it included some hardwood trees.

The surface layer is light brownish-gray silt loam or silty clay loam that is 7 to 14 inches thick. The subsurface layer is light-gray silt loam that is about 9 inches thick. The subsoil is dark grayish-brown clay loam or silty clay and is much mottled.

Lightning soils are near the Verdigris and Osage soils. They are lighter colored, more mottled, and less well drained than the Verdigris soils and are lighter colored and less clayey than the Osage soils. Also, the Lightning soils have a light-colored subsurface layer, which is lacking in the Verdigris and Osage soils.

The Lightning soils are low in organic matter, have a very strongly acid subsoil, and are very slowly permeable. Wetness makes tillage difficult.

Most areas of these soils are in grass and trees. The grassed areas are used for hay and grazing. Some of the better drained areas are used for corn, wheat, oats, and grain sorghum, and in some places tame pasture crops are grown. The soils are well suited to fescue.

Lightning silt loam (Ln).—This is the only soil of the Lightning series mapped in this county. In areas that are clean tilled, the soil is gray when dry and brownish when wet.

Included with this soil in mapping are areas of Verdigris and Osage soils that are too small to be mapped separately.

Lightning silt loam can be cultivated, but it generally is best suited to grass. Most areas are used for range or native grass hay. In some places corn, wheat, oats, and grain sorghum are grown, but yields are moderately low. Dominant on range are native cordgrass, bluestem, and switchgrass. In the wet areas cordgrass is dominant.

If this soil is cultivated, drainage is generally needed. Returning crop residues to the soil or growing green-manure crops are methods of adding organic matter. These practices also increase the intake of water, prevent surface crusting, and prevent puddling. A grass or a legume is needed in the cropping system at least one-third of the time. Yields increase in most years if fertilizer is applied. Lime is needed to correct acidity. (Capability unit IIIw–1; Heavy Bottomland range site)

Mine Pits and Dumps (Mp)

This miscellaneous land type is in the north-central part of the county. It consists of piles of rock and chat from zinc and lead mines. The larger piles cover 40 acres or more, and some of them can be seen for miles.

In some areas there is only a thin covering of rock and chat. In many places drainageways are blocked by rock and chat and nearby areas are ponded or made swampy.

Seepage from these areas makes nearby soils, which are otherwise well drained, wet in many places.

Mapped with this unit are small areas that have vegetation on them. Most areas of this mapping unit are without vegetation.

This miscellaneous land type has little value for agriculture, except as areas for wildlife. (Capability unit VIIIs–1; not assigned to a range site)

Newtonia Series

The soils of the Newtonia series are deep, well drained, and gently sloping to moderately sloping. These soils have formed under tall prairie grass in material weathered from limestone that contains some chert. Most of the areas are near Fairland.

The surface layer, a brown or reddish-brown silt loam, is 12 to 18 inches thick. The subsoil is brown to yellowish-red, or reddish-yellow, granular silty clay loam. Depth to bedrock or chert averages about 44 inches.

Newtonia soils are near soils of the Summit and Dennis series and soils of the Newtonia-Sogn complex. They are redder, less clayey, and more permeable than the Summit soils.

The Newtonia soils are medium acid and moderately permeable. Their supplies of organic matter and plant nutrients are good, and they are easily tilled.

These soils are productive, and most of them are cultivated. The principal crops are wheat, oats, corn, grain sorghum, and soybeans. Most of the alfalfa grown in Ottawa County is grown on Newtonia soils.

Newtonia silt loam, 1 to 3 percent slopes (NaB).—The surface layer of this gently sloping soil is about 15 inches thick.

Mapped with this soil are areas of Dennis and Summit soils. These included soils are too small to be mapped separately.

Newtonia silt loam, 1 to 3 percent slopes, is well suited to cultivation. Except for small tracts surrounded by other soils, the areas of this soil are cultivated.

When this soil is cultivated, it is likely to erode if it is not protected. Therefore, practices that control erosion and maintain organic matter and fertility are needed. Crops on this soil respond well if phosphate and nitrogen are applied and other good management is used. Alfalfa can be grown successfully if lime and phosphate are applied.

Terracing and contour farming help control erosion. Returning crop residues to the soil and growing green-manure crops add organic matter. These practices also help maintain soil structure, increase the intake of water, and increase yields. A grass or a legume is needed in the cropping system at least one-fourth of the time. Yields are increased in most years if fertilizer is applied. (Capability unit IIe–2; Loamy Prairie range site)

Newtonia silt loam, 3 to 5 percent slopes (NaC).—The surface layer of this moderately sloping soil is slightly thinner than that of Newtonia silt loam, 1 to 3 percent slopes.

This soil is suited to cultivation, and most of it is cultivated. Yields are lower than on Newtonia silt loam, 1 to 3 percent slopes, because the slope is stronger, runoff is greater, and less moisture is stored for plants to use. Nevertheless, crops on this soil respond well if nitrogen and phosphate are applied.

This soil is subject to erosion if it is cultivated and not protected. Terracing and contour farming are needed. Returning crop residues to the soil will improve the tilth of the surface layer and increase the intake of water. A grass or a legume is needed in the cropping system at least one-third of the time. (Capability unit IIIe–1; Loamy Prairie range site)

Newtonia silt loam, 2 to 5 percent slopes, eroded (NaC2).—The surface layer of this moderately eroded soil is brown and silty and is streaked and splotched with red. It ranges from 0 to 12 inches in thickness but averages about 6 inches. Erosion has caused rills and in most places has removed much of the surface layer. In a few places all of the surface layer is gone and red material formerly in the subsoil is on the surface.

Mapped with this soil are areas of Summit and Dennis soils. These included soils are too small to be mapped separately.

Newtonia silt loam, 2 to 5 percent slopes, eroded, has all been cultivated, but much of the acreage is now in bermudagrass, lespedeza, and yellow hop clover. The rest is cultivated, and the main crops are wheat, oats, and grain sorghum.

This soil is suited to cultivation, and if it is protected and well managed otherwise, yields are fair. It is more erodible than Newtonia silt loam, 3 to 5 percent slopes, because its surface layer is thinner. Because of erosion, much of the fertility has been lost.

If this soil is cultivated, terracing, contour farming, and practices that maintain or increase organic matter and fertility are needed. Returning crop residues to the soil, growing green-manure crops, and adding other organic matter improve tilth of the surface layer, increase intake of water, and increase yields. A grass or a legume is also needed in the cropping system at least one-third of the time. Yields are increased if fertilizer is applied (Capability unit IIIe–3; Loamy Prairie range site)

Newtonia-Sogn complex (Ns).—This soil complex is made up of areas of Newtonia silt loam and of Sogn soils that are about equal in acreage. These areas are too small and intermingled to be mapped separately. They are gently to moderately sloping and are mostly in the Fairland community. Slopes range from 1 to 8 percent.

The Newtonia soil in this complex is darker colored than the other Newtonia soils described but is otherwise similar. Sogn soils are very shallow over limestone. They are dark colored, clayey, and granular.

Mapped with this complex are areas of Dennis and Woodson soils. These included soils are too small to be mapped separately.

The soils in the Newtonia-Sogn complex are stony and droughty. They are not suited to cultivation and should be kept in grass. The areas in grass must be managed carefully, since, if they are overgrazed, the desirable grass is replaced by weeds and sprouts. (Capability unit VIs–1; Newtonia silt loam, Loamy Prairie range site; Sogn soils, Very Shallow range site)

Osage Series

The soils of the Osage series are deep, somewhat poorly drained, and nearly level. They are on flood plains along the Neosho River and its tributaries. They are forming in alluvium washed from soils of the prairies. The native

vegetation was mainly tall, coarse grass that required much water, but it included some hardwood trees.

The surface layer is very dark gray or black silty clay about 13 inches thick. It is granular and takes in water slowly. The subsoil is gray or dark-gray, mottled, blocky or massive silty clay that takes water very slowly.

Osage soils are near the Verdigris and Lightning soils. They are darker colored and more clayey than the Verdigris and Lightning soils and are less well drained than the Verdigris soils.

The supplies of organic matter and plant nutrients are high in these soils. Acidity varies. The high content of clay, very slow permeability, and wetness make these soils difficult to cultivate.

Most areas of the Osage soils remain in native grass and are used for hay or grazing. Some of the better drained areas are cultivated, and wheat, oats, and grain sorghum are the principal crops.

Osage silty clay (Os).—This is the only soil of the Osage series mapped in this county. It stays wet for a long time after a rain, and when it is dry the surface crusts and cracks.

Osage silty clay can be cultivated but is best used for grass. Cultivated areas require drainage; otherwise, the crop is generally drowned out in spots, and sometimes the entire crop is lost. The soil is droughty in dry seasons. In the meadows, cordgrass is dominant, and large amounts of this grass and other prairie grasses are harvested.

If the soil is cultivated, returning crop residues to the soil and growing green-manure crops improve tilth of the surface layer, increase intake of water, and improve yields. A grass or a legume crop should be grown at least one-half of the time and returned to the soil.

If feasible, livestock should be removed from the pastures in wet seasons to prevent trampling and puddling of the soil. (Capability unit IIIw-1; Heavy Bottomland range site)

Parsons Series

The Parsons series consists of deep, nearly level or gently sloping upland soils that are somewhat poorly drained. These soils are on broad flats and gentle slopes in the central and western parts of the county. They formed under a dense cover of tall prairie grass in material weathered from shale.

The surface layer is grayish brown or dark grayish brown and is silty. It is 8 to 12 inches thick. Below is a layer of light-gray silt loam about 3 inches thick. The subsoil is a mottled dark grayish-brown or yellowish-brown claypan. It is blocky in structure and very slowly permeable.

Parsons soils are near the Bates, Dennis, and Taloka soils. They are more slowly permeable than the Dennis soils and their subsoil contains more clay. They have thinner surface and subsurface layers than the Taloka soils.

The Parsons soils are strongly acid in the upper part of the profile and medium acid to slightly acid in the subsoil. Their supplies of organic matter and plant nutrients are low or medium. These soils are droughty. They store large quantities of water but release it to plants slowly. Runoff is slow on the flats and medium on the slopes. Except in wet seasons, these soils are easily tilled. On the flat areas, drainage is blocked in places by improper tillage, and wet spots result.

Most areas of the Parsons soils are cultivated. Wheat, oats, grain sorghum, and soybeans are the principal crops.

Parsons silt loam, 0 to 1 percent slopes (PaA).—In this nearly level soil, depth to the claypan subsoil is about 13 inches.

Mapped with this soil are areas of Dennis and Taloka soils. These included soils are too small to be mapped separately.

Most of Parsons silt loam, 0 to 1 percent slopes, is cultivated. The slow drainage and the impervious subsoil cause the soil to be wet for a few days after a rain. The soil stores large quantities of water but releases it to plants slowly. As a result, plants wilt in places, even though there is still moisture in the soil.

This soil is better suited to wheat and oats that mature before the dry season, or to grain sorghum, than to other crops.

Except on long slopes where water concentrates, erosion is not serious. Terraces can be used to keep water from concentrating, but all terraced areas should be farmed on the contour. Returning crop residues to the soil, plowing down a grass or legume that is grown in the cropping system at least one-fourth of the time, and similar practices are needed. These practices increase the intake of water and, thus, make use of the large storage capacity of this soil. (Capability unit IIs-1; Claypan Prairie range site)

Parsons silt loam, 1 to 3 percent slopes (PaB).—In this gently sloping soil, the thickness of the combined surface and subsurface layers averages about 11 inches.

Mapped with this soil are areas of Parsons silt loam, 0 to 1 percent slopes, and of Dennis silt loams. These included soils are too small to be mapped separately.

Most of Parsons silt loam, 1 to 3 percent slopes, is cultivated. Wheat, oats, and grain sorghum are the main crops.

Runoff is fairly rapid on this soil, and the subsoil is very slowly permeable. As a result, the hazard of erosion is moderate.

Terracing and contour farming are needed. Also, a grass or a legume is needed in the cropping system about one-third of the time. (Capability unit IIIe-2; Claypan Prairie range site)

Parsons silt loam, 1 to 3 percent slopes, eroded (PaB2).—The surface layer of this moderately eroded soil is thinner than that of Parsons silt loam, 1 to 3 percent slopes. Erosion has caused rills and removed much material from the surface layer. As a result, there are gumbo spots in most places. Depth to the subsoil ranges from 4 to 11 inches but averages about 6 inches.

Mapped with this soil are areas of the other Parsons soils and of Dennis soils. These included soils are too small to be mapped separately.

All of Parsons silt loam, 1 to 3 percent slopes, eroded, has been cultivated, but most of it is now in pasture or is idle. Occasionally, a cultivated crop can be grown in the cropping system in rotation with perennial grasses or legumes. However, the soil is best used for grass. The hazard of erosion is serious, since the surface layer is thin.

Terracing, contour farming, returning crop residues to the soil, growing green-manure crops, and similar practices are needed. These practices help control further erosion

and to increase organic matter and fertility. A green-manure crop should be grown about once in 3 years. Yields are increased if fertilizer is applied. (Capability unit IVe-1; Claypan Prairie range site)

Riverton Series

The soils of the Riverton series are deep, gravelly, moderately sloping, and well drained to somewhat excessively drained. Most areas are small and occur west of the Spring River. These soils formed under tall prairie grass in old alluvium on the uplands.

The surface layer, a dark-brown or dark grayish-brown gravelly loam, is 6 to 16 inches thick. The subsoil ranges from very gravelly light clay loam to very gravelly heavy silty clay loam.

Riverton soils are near the Bates, Collinsville, and Dennis soils. They are more gravelly than those soils, and their parent material is old alluvium rather than sandstone or shale.

The Riverton soils are strongly acid to very strongly acid. They have a fair supply of organic matter and plant nutrients and are in good tilth. Permeability is moderately rapid, and runoff is medium to rapid.

Most of the acreage is in native grass used for hay or grazing. Wheat, oats, grain sorghum, and tame pasture crops are grown in places.

Riverton gravelly loam, 3 to 5 percent slopes (RvC).—This is the only soil of the Riverton series mapped in this county.

Mapped with this soil are areas of Bates and of Collinsville soils. These included soils are too small to be mapped separately.

If Riverton gravelly loam, 3 to 5 percent slopes, is cultivated, terracing, contour farming, returning crop residues to the soil, the growing of green-manure crops, and other practices of intensive management are needed. These practices help to control erosion and to maintain organic matter and soil structure. Because of the very gravelly subsoil, water moves rapidly through this soil. Therefore, not enough moisture is retained to carry plants through long dry periods and yields are reduced. Yields are increased in most years, however, if a fertilizer that contains nitrogen, phosphorus, and potassium is applied.

On this soil, native range or pasture in good or excellent condition consists dominantly of bluestem, switchgrass, and Indiangrass. In areas that are overgrazed, these grasses are replaced by broomsedge, annual grasses, weeds, brush, and scrubby trees. Controlling grazing so that about half of the current growth is left each year helps to maintain or improve the condition of the grasses and to obtain high yields. (Capability unit IIIe-1; Loamy Prairie range site)

Sogn Series

In the Sogn series are shallow, well-drained, and gently to moderately sloping soils. These soils are on uplands, mostly near Fairland. They formed under mid prairie grasses in material from limestone.

The surface layer is very dark gray, clayey, and granular, and it takes in water readily. It ranges from 2 to 15 inches in thickness but averages about 10 inches. Limestone is exposed in about 30 percent of the acreage.

Because the areas are small and intricately mixed with areas of Newtonia silt loam, the Sogn soils are not mapped separately in this county. They are mapped in a Newtonia-Sogn complex, and the complex is described under the Newtonia series.

Summit Series

In the Summit series are deep, well-drained, gently sloping soils. These soils are mostly near Fairland. They formed under a dense cover of tall prairie grass in material weathered from limestone and soft calcareous shale.

The surface layer, a very dark gray, granular silty clay loam, is 10 to 16 inches thick. The subsoil is olive colored, blocky silty clay loam and is finely mottled. It takes water slowly and stores large quantities of it for plants to use.

Summit soils are near the Dennis, Newtonia, Sogn, and Woodson soils. Their surface layer is darker colored and finer textured than that in the Dennis soils. Also, it is less granular, more clayey, and more slowly permeable than the surface layer of the Woodson soils.

The Summit soils are slightly acid in the surface layer and neutral to mildly alkaline in the lower layers. They have good supplies of organic matter and plant nutrients and are moderately productive. Summit soils are slowly permeable and somewhat difficult to cultivate. Nevertheless, most of the acreage is cultivated. The principal crops are wheat, oats, corn, grain sorghum, and soybeans.

Summit silty clay loam, 1 to 3 percent slopes (SuB).—This is the only soil of the Summit series mapped in this county. The areas are generally small.

Mapped with this soil are areas of Newtonia, Dennis, and Woodson soils. These included soils are too small to be mapped separately.

If Summit silty clay loam, 1 to 3 percent slopes, is cultivated, practices that control erosion, maintain organic matter and fertility, and build up soil structure are needed. In most places this soil is subject to runoff from higher areas. Consequently, terraces are needed to divert the water away from the areas, unless crops that yield large amounts of residue are grown in the cropping system at least 1 in 2 years. The supply of organic matter can be maintained and tilth improved if a grass and a legume are used in the cropping system. Yields are increased if a fertilizer that contains nitrogen and phosphate is applied. (Capability unit IIe-1; Loamy Prairie range site)

Taloka Series

In the Taloka series are deep, nearly level soils on uplands. These soils are on broad flats in the northern and western parts of the county. They formed under tall prairie grass in old alluvium.

The surface layer is grayish-brown silt loam 10 to 20 inches thick. Below is a very pale brown layer that is 6 to 10 inches thick. This layer rests on grayish-brown or dark grayish-brown, blocky, mottled clay that takes in water very slowly.

Taloka soils are near the Bates, Choteau, Dennis, and Parsons soils. They are similar to the Parsons soils, but the claypan subsoil is at a greater depth in the Taloka

soils. They have a more clayey subsoil than that in the Choteau soils and take in water more slowly.

The Taloka soils are strongly acid to very strongly acid. They have good supplies of organic matter and plant nutrients, but the content of organic matter is difficult to maintain. Runoff is slow. In places drainage is blocked by improper tillage and causes ponding. Except in wet seasons, Taloka soils are easily tilled.

These soils are mostly cultivated. The principal crop is wheat, but oats, corn, grain sorghum, and soybeans are also grown.

Taloka silt loam, 0 to 1 percent slopes (TaA).—This is the only soil of the Taloka series mapped in this county. It is nearly level and is on uplands. The surface layer is grayish-brown silt loam that is very gray when dry.

Mapped with this soil are small areas of Dennis and Parsons soils. These included soils are too small to be mapped separately.

The surface and subsurface layers of Taloka silt loam, 0 to 1 percent slopes, take in water readily. During a heavy rain, the upper layers are soon saturated and the rainwater then runs off. Erosion is not serious except on long slopes or where water concentrates. In these places terraces are needed. If this soil is cultivated, practices are needed that maintain soil structure and increase organic matter.

Some areas of this soil are still in grass and are used for grazing or hay. If the areas are overgrazed, the native bluestem, switchgrass, and Indiangrass are killed and replaced by annual grasses and weeds. (Capability unit IIs-1; Loamy Prairie range site)

Verdigris Series

The soils of the Verdigris series are deep, well drained or moderately well drained, and nearly level. These soils are on flood plains, mostly along the Neosha River and its tributaries. They are forming in alluvium washed from soils in the prairies. The native vegetation was a forest of lowland hardwoods with tall prairie grasses in the openings.

The surface layer, a silt loam or clay loam, is grayish brown to very dark grayish brown and 6 to 20 inches thick. The subsoil is pale-brown silt loam or light clay loam. It takes in water readily and stores large quantities of it for plants to use.

Verdigris soils are near the Lightning and Osage soils and are better drained than those soils. They are darker colored than the Lightning soils and lack the light-colored subsurface layer that is in those soils. They are lighter colored and are less clayey throughout the profile than the Osage soils.

The Verdigris soils are generally medium acid. They have good supplies of organic matter and plant nutrients, are moderately permeable, and are easily tilled.

Most areas of these productive soils are cultivated. Corn is the principal crop, but wheat, oats, grain sorghum, and soybeans are also grown.

Verdigris silt loam (Vd).—This is the only soil of the Verdigris series mapped in this county, and it is one of the most productive soils in the county.

About 10 percent of the acreage of this soil consists of Verdigris clay loam. Also included with this soil in mapping are small areas of Lightning soils and of Osage soils.

Verdigris silt loam has no serious limitations. Floods occasionally deposit silt on the areas, which adds new fertile soil. Cutting, or other damage seldom occurs. Returning crop residues to the soil, the growing of green-manure crops, and similar good management are needed. These practices maintain organic matter and fertility and build up soil structure. They also improve tilth of the surface layer, increase intake of water, and increase yields. Yields are also increased in most years if fertilizer is applied.

Trees can be grown successfully on this soil for posts. (Capability unit I-1; Loamy Bottomland range site)

Woodson Series

In the Woodson series are deep, nearly level or gently sloping soils on uplands. These soils are moderately well drained to somewhat poorly drained. They are in wide, shallow drainageways and on flats, mostly in the southern part of the county. Woodson soils formed under tall prairie grass in material weathered from clayey shale.

The surface layer is black silty clay loam 8 to 15 inches thick. The subsoil is a very dark gray, blocky or massive clay that takes in water very slowly.

The Woodson soils are near the Dennis, Parsons, and Summit soils. They have a finer textured surface layer than that of the Parsons soils and lack the light-colored subsurface layer that is in those soils. They have a less granular surface layer than the Summit soils and are more clayey and more slowly permeable.

The Woodson soils are neutral in reaction. Their supplies of organic matter and plant nutrients are good. Because of their high clay content, these soils are very slowly permeable and are difficult to cultivate. Runoff is slow on the flats and medium on the slopes. Internal drainage is very slow.

Most areas of the Woodson soils are cultivated. Wheat, oats, and grain sorghum are the principal crops.

Woodson silty clay loam, 0 to 1 percent slopes (WoA).—This nearly level soil is black, and it is often referred to as gumbo.

Mapped with this soil are areas of Summit soils and of Osage soils. These included soils are too small to be mapped separately.

Woodson silty clay loam, 0 to 1 percent slopes, stays wet for several days after a rain. During a rain, the surface layer is soon saturated, and then water soaks in very slowly. When the soil is dry, the surface crusts and cracks. This soil stores large quantities of water, but, because of the content of clay, it holds it tightly. Consequently, plants often wilt even though the soil still contains moisture. The hazard of erosion is not serious.

On this soil, corn, soybeans, and other crops that mature during the dry season are often damaged by drought. Therefore, small grain and grain sorghum are the principal crops. Returning crop residues to the soil, the growing of green-manure crops, and other practices that add large amounts of organic material are needed. Yields are increased if a fertilizer that contains phosphate and nitrogen is applied. (Capability unit IIs-1; Claypan Prairie range site)

Woodson silty clay loam, 1 to 3 percent slopes (WoB).—The surface layer of this gently sloping soil averages about 10 inches in thickness.

Mapped with this soil are small areas of Summit soils and of Parsons soils. These included soils are too small to be mapped separately.

Erosion is the most serious hazard on Woodson silty clay loam, 1 to 3 percent slopes. The soil is also droughty.

This soil is suited to cultivation. Terracing, contour farming, returning crop residues to the soil, and the growing of green-manure crops are needed. These practices help to control erosion and maintain organic matter and fertility. Except in extremely dry years, yields are increased if fertilizer is applied. (Capability unit IIIe-2; Claypan Prairie range site)

Formation, Classification, and Morphology of Soils

In this section the formation of the soils of Ottawa County is discussed and the outstanding morphologic characteristics of the soils and their relationship to the factors of soil formation are given. Also discussed is the classification of the soils by higher categories. Physical and chemical data are limited for these soils. Therefore, the discussion is correspondingly incomplete.

Factors of Soil Formation

Soil is formed by weathering and other processes that act on the material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend upon (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the factors of soil formation have acted on the soil material.

Climate and plant and animal life are active factors of soil formation. They act on the parent material accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of profile that can be formed and in extreme cases determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. The amount of time may be much or little, but generally a long time is required for distinct horizons to develop.

The factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made about the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Classification and Morphology of Soils

Soils are classified in various categories to make it easier to remember them and to organize and apply knowledge about their behavior to farms, ranches, counties, or to the soils of continents. The system of soil classification now being used in the United States consists of six categories, one above the other.[10] Beginning at the top, the six categories in the system of soil classification are the order, suborder, great soil group, family, series, and type.

The categories of the suborder and family have never been fully developed and, therefore, have been little used. In soil classification attention has largely been given to the recognition of soil types and series within counties or comparable areas and to the subsequent grouping of the series into great soil groups and orders.

The lower categories of classification, the soil series, type, and phase, are defined in the section "How Soils are Mapped and Classified." The soil series are classified into higher categories, great soil groups and soil orders.[11] In a great soil group are soils that have fundamental characteristics in common. All three soil orders—the zonal, intrazonal, and azonal—are represented in this county.

The zonal order is made up of soils that have a well-developed soil profile. The soils reflect the predominant influence of climate and plant and animal life in their formation. In Ottawa County the Brunizems, Reddish Prairie soils, and Red-Yellow Podzolic soils are the great soil groups in the zonal order.

Soils in the intrazonal order have more or less well-developed, genetically related horizons that reflect the dominant influence of some local factor, such as relief or parent material, over the effects of climate and plant and animal life. Planosols are the only great soil group in the intrazonal order in this county.

The azonal order is made up of soils that, because of youth, resistant parent material, or steepness, lack well-developed profiles. In this county the Alluvial soils and Lithosols are the great soil groups in the azonal order.

In table 8 the soil series are classified by order and great soil group and some important characteristics of each series are given. The great soil groups are described and the soils within each group are listed in the pages that follow.

Brunizems

The Brunizems are a group of zonal soils that are in the central part of the United States. These soils formed under tall prairie grasses in a fairly humid, temperate climate. Typically, Brunizems have an acid, thick, very dark brown to black A horizon rich in organic matter; a brown B horizon that may or may not be mottled; and lighter colored parent material.

In this county the parent materials are mainly shale, sandstone, or limestone, but they also include reconsolidated alluvium and loess.

The Bates, Choteau, Craig, Dennis, Summit, and Woodson soils are classified as Brunizems in Ottawa County.

Reddish Prairie soils

Reddish Prairie soils are mostly in the southern part of the United States. These soils formed under tall and mixed prairie grasses in a humid to subhumid, warm-temperate climate.

Reddish Prairie soils generally have a dark reddish-brown, slightly acid to medium acid surface soil that grades through somewhat finer textured reddish material

[10] SOILS AND MEN. pp. 979-1001. U.S. Dept. of Agr. Ybk. 1938.

[11] THORP, JAMES, AND SMITH, GUY D. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117-126. 1949.

to the parent material. Depth to parent material is between 2 and 5 feet.

The Eldorado, Newtonia, and Riverton soils are classified as Reddish Prairie soils in Ottawa County.

Red-Yellow Podzolic soils

Red-Yellow Podzolic soils belong to the zonal order. These soils formed under forest in a humid, warm-temperate climate. They have a thin surface layer of litter and acid humus, and a thin organic-mineral A1 horizon over a thicker, light-colored, leached A2 horizon. The B horizon is a thick, red, yellowish-red, or yellowish-brown layer that shows some accumulation of clay and sesquioxides. The C horizon is fairly siliceous.

In Ottawa County the Baxter, Bodine, and Etowah soils are classified as Red-Yellow Podzolic soils.

Planosols

Planosols belong to the intrazonal order. These soils have one or more horizons that are abruptly separated from and contrast sharply to an adjacent horizon. The contrast may result from high clay content, cementation, or compactness. Some Planosols have B horizons that are very high in clay beneath A horizons that are low in clay, the two being separated by an abrupt boundary. Other Planosols have a fragipan—a compact, or brittle, seemingly cemented horizon—below a B horizon that has some clay accumulation.

In Ottawa County the Planosols are nearly level. The Lawrence, Lightning, Parsons, and Taloka series are classified as Planosols in this county.

Alluvial soils

Alluvial soils are in the azonal order and are forming in materials transported and recently deposited on flood plains. Each time the areas are flooded, the soils receive fresh deposits of soil material or part of the old surface material is removed. As a result, the original material has not been modified or is only weakly modified by soil-forming processes.

The Huntington, Kaw, Osage, and Verdigris soils in this county are classified as Alluvial soils. The Huntington soils are forming in alluvium washed from soils from cherty limestone, but the other soils are forming in sediments washed from soils of the prairies.

Lithosols

Lithosols belong to the azonal order. These soils typically have little or no profile development. They consist of freshly and imperfectly weathered rock fragments and are generally on steep slopes. Lithosols do not have genetically related horizons. In Ottawa County the Collinsville and Sogn soils are classified as Lithosols.

Detailed Descriptions of Soil Series

In this section the soil series in the county are discussed in alphabetical order. In addition, a representative profile of each series is described in detail. The great soil group is given for each series for easy cross reference to table 8.

BATES SERIES

The Bates series consists of moderately deep, gently sloping to moderately sloping, well-drained, noncalcareous soils of the uplands. These soils occupy small areas throughout the western part of the county. They belong to the Brunizem great soil group. Bates soils formed in material weathered from noncalcareous sandstone and interbedded shale.

These soils are associated with soils of the Dennis series. They are coarser textured throughout the profile than those soils and have coarser textured parent material. They are also associated with the Parsons soils, which are Planosols, and with the Collinsville soils, which are Lithosols.

Representative profile of Bates loam, 3 to 5 percent slopes, in a cultivated field (400 feet west of the southeast corner of sec. 1, T. 27 N., R. 23 E):

A1—0 to 13 inches, dark grayish-brown (10YR 4/2,[12] dry) loam, very dark grayish brown (10YR 3/2, moist); weak, fine, granular structure; very friable; moderately permeable; slightly acid (pH 6.5); gradual boundary.

B1—13 to 18 inches, brown (10YR 5/3, dry) heavy loam, dark brown (10YR 4/3, moist); a few, fine, prominent mottles of strong brown; moderate, medium, granular structure; very friable; moderately permeable; medium acid (pH 6.0); gradual boundary.

B2—18 to 33 inches, light yellowish-brown (10YR 6/4, dry) light clay loam, yellowish brown (10YR 5/4, moist); common, fine, distinct mottles of dark reddish brown and red; moderate, medium and fine, granular structure; friable; moderately permeable; slightly acid (pH 6.3); abrupt boundary.

D—33 inches +, weathered sandstone.

The A horizon is grayish brown or dark grayish brown and 10 to 16 inches thick. The B2 horizon ranges from light yellowish brown to reddish brown in color and from light clay loam to sandy clay loam in texture. Depth to sandstone ranges from 20 to 40 inches but is generally about 30 inches.

In about one-third of the acreage, the slope is less than 3 percent. In places the soils are shallow. Here the soil horizons are thinner than in the representative profile described and depth of the solum averages about 17 inches.

BAXTER SERIES

In the Baxter series are deep, gently sloping to moderately sloping, well-drained soils of the uplands. These soils are on smooth ridgetops in the Ozark Plateau, mostly east of the Spring River. They are in the Red-Yellow Podzolic great soil group. Baxter soils formed in material weathered from cherty limestone of the Boone formation of Mississippian age. The native vegetation was a forest, mostly of the oak-hickory type, but some tall grass grew in the openings.

The Baxter soils have a thin, organic-mineral surface layer, a light-colored, silty subsurface layer, and a yellowish-red or red subsoil. In many places there is chert throughout the profile. In cultivated areas material that formerly was in the subsurface layer has been mixed into the surface layer. As a result, in these places the present surface layer is light colored.

Baxter soils are associated with the Bodine and Lawrence soils. They are less cherty or stony than the Bodine soils, are less permeable, and have greater moisture-storage capacity. They are better drained, redder, and less mottled than the Lawrence soils.

[12] Symbols express color notations. These and other terms are described in the SOIL SURVEY MANUAL, U.S. Dept. Agr. Handb. No. 18, or in the Glossary.

TABLE 8.—*Classification of soil series by higher categories and some important characteristics of each series*

Great soil group and series	Texture of typical B horizon or subsoil	Average depth of the solum	Parent material	Slope and position
ZONAL				
Brunizems:		*Inches*		
Bates	Clay loam	30	Sandstone interbedded with shale.	Gently to moderately sloping uplands.
Choteau	Silty clay loam	40	Old alluvium	Nearly level to gently sloping high terraces.
Craig	Clay loam	26	Cherty limestone	Gently to moderately sloping uplands.
Dennis	Clay loam	29	Sandy and clayey shale.	Nearly level to moderately sloping uplands.
Summit	Silty clay	42	Limestone	Gently sloping uplands.
Woodson	Clay	22	Clayey shale	Nearly level to gently sloping uplands.
Reddish Prairie soils:				
Eldorado	Very cherty clay loam	24	Cherty limestone	Gently to strongly sloping uplands.
Newtonia	Silty clay loam	56	Limestone	Gently to moderately sloping uplands.
Riverton	Very gravelly clay loam	39	Old alluvium	Moderately sloping high terraces.
Red-Yellow Podzolic soils:				
Baxter	Silty clay	31	Cherty limestone	Nearly level to moderately sloping uplands.
Bodine	Very gravelly silty clay loam	60	Cherty limestone	Gently sloping to steep uplands.
Etowah	Gravelly clay loam	40	Old alluvium	Nearly level to strongly sloping terraces.
INTRAZONAL				
Planosols:				
Lawrence	Silty clay loam	33	Cherty limestone	Nearly level uplands.
Lightning	Silty clay	34	Alluvium	Nearly level bottom lands.
Parsons	Clay	38	Shale	Nearly level to gently sloping uplands.
Taloka	Clay	46	Old alluvium	Nearly level terraces.
AZONAL				
Alluvial soils:				
Huntington	Gravelly silty clay loam	(1)	Recent alluvium	Nearly level bottom lands.
Kaw	Clay loam	(1)	Recent alluvium	Nearly level bottom lands.
Osage	Clay	(1)	Recent alluvium	Nearly level bottom lands.
Verdigris	Silt loam	(1)	Recent alluvium	Nearly level bottom lands.
Lithosols:				
Collinsville	(2)	7	Sandstone	Moderately sloping to steep uplands.
Sogn	(2)	10	Limestone	Gently to strongly sloping uplands.

[1] The solum shows little development.
[2] No subsoil development.

Representative profile of Baxter silt loam, 1 to 3 percent slopes, in a cultivated field on a 2 percent gradient; plowing has mixed material from the upper part of the A2 horizon into the A1 horizon (1,340 feet west of the northeast corner of sec. 34, T. 28 N., R. 24 E.):

A1p—0 to 9 inches, brown (10YR 5/3, dry) silt loam, dark brown (10YR 3/3, moist); weak, medium and fine, granular structure; friable; moderately permeable; medium acid (pH 6.0); clear boundary.

A2—9 to 15 inches, pale-brown (10YR 6/3, dry) silt loam, dark brown (10YR 4/3, moist); weak, fine, granular structure; friable; moderately permeable; strongly acid (pH 5.5); clear boundary.

B1—15 to 18 inches, yellowish-red (5YR 4/6, dry and moist) silty clay loam; moderate, medium, subangular blocky structure; silt coatings on peds in places; friable; moderately permeable; strongly acid (pH 5.5); gradual boundary.

B2—18 to 25 inches, yellowish-red (5YR 4/6, dry and moist) silty clay; moderate, medium and fine, subangular blocky structure; clay skins on peds in places; firm when moist, slightly hard when dry; slowly permeable; very strongly acid (pH 5.0); gradual boundary.

B3—25 to 31 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) clay; many, medium, distinct mottles of red, yellowish-brown, and brown; moderate, medium, blocky structure; clay skins are evident; firm when moist, hard when dry; slowly permeable; contains chert fragments; gradual boundary.

C—31 to 40 inches +, red (2.5YR 5/8, dry; 4/8, moist) very cherty silty clay; common, medium, prominent mottles of brown; the volume of chert ranges from 40 percent in the upper part of this horizon to 98 percent in the lower part.

The texture of the B2 horizon ranges from silty clay loam to silty clay or clay. Minor variations in color

occur in all horizons. Slopes range from 1 to 5 percent. The subsoil is moderately or slowly permeable.

In some places there is a small amount of chert throughout the profile. There is generally chert on the surface in cultivated fields, but it does not hinder tillage.

BODINE SERIES

In the Bodine series are deep, cherty or stony, well-drained to somewhat excessively drained soils of the uplands. These soils are on smooth ridgetops and steep breaks in the Ozark Plateau and are the most extensive soils in the county. They are in the Red-Yellow Podzolic great soil group. Bodine soils formed in material from cherty limestone of the Boone formation of Mississippian age. The native vegetation was a forest with tall grass growing in the openings.

The Bodine soils have a thin, organic-mineral surface layer and a thick, light-colored A2 horizon. They vary in slope and in the size and amount of chert or stone they contain. The stony soils mostly have a slope of 12 to 50 percent. Therefore, the soil was mapped as stony where the slope is more than 12 percent, even though some of it may not be stony.

Bodine soils are associated with the Baxter and Lawrence soils. They are more cherty or stony in the upper soil layers than those soils and are less clayey but more permeable.

Representative profile of Bodine very cherty silt loam, 1 to 8 percent slopes, in an undisturbed site on a gradient of about 5 percent (southeast corner of sec. 14, T. 27 N., R. 24 E.):

A1—0 to 2 inches, grayish-brown (10YR 5/2, dry) very cherty silt loam, dark grayish brown (10YR 4/2, moist); chert up to 2 inches in diameter makes up about 50 percent of the volume; weak, fine, granular structure; very friable; moderately permeable; slightly acid (pH 6.5); clear boundary.

A2—2 to 16 inches, pale-brown (10YR 6/3, dry) very cherty silt loam, brown (10YR 5/3, moist); chert up to 2 inches in diameter makes up 50 to 60 percent of the volume; weak, fine, granular structure; very friable; moderately rapid permeability; strongly acid (pH 5.5); gradual boundary.

B1—16 to 32 inches, brown (7.5YR 5/4, dry) very cherty light silty clay loam, dark brown (7.5YR 4/4, moist); chert makes up about 75 percent of the volume and obscures the structure; rapidly permeable; very strongly acid (pH 5.0); gradual boundary.

B2—32 to 60 inches +, light yellowish-brown (10YR 6/4, dry) very cherty silty clay loam, yellowish brown (10YR 5/4, moist); coarsely mottled with brown and gray; chert up to 8 inches in diameter makes up 80 to 90 percent of the volume and obscures the structure; rapidly permeable; very strongly acid (pH 4.8).

On the surface, chert up to 6 inches in diameter ranges from a few scattered pebbles to a complete cover. The color of the B horizons ranges from brown and yellowish brown to red, and the texture of the fine material in them from light silty clay loam to heavy clay loam. Slopes range from 1 to 8 percent.

In places there are beds of tripoli at a depth below 40 inches.

Representative profile of Bodine stony silt loam, steep, in an undisturbed site on a slope of 15 percent (1,320 feet west of the southeast corner of sec. 26, T. 27 N., R. 24 E.):

A1—0 to 2 inches, black (10YR 2/1, dry and moist) stony silt loam that is largely decayed vegetation; almost structureless; mildly alkaline (pH 7.5); clear boundary.

A2—2 to 14 inches, very pale brown (10YR 8/3, dry) very cherty silt loam, pale brown (10YR 6/3, moist); weak, fine, granular structure; very friable; moderately permeable; very strongly acid (pH 5.0); gradual boundary.

B1—14 to 30 inches, light-brown (7.5YR 6/4, dry) very cherty light silty clay loam, brown (7.5YR 5/4, moist); angular chert up to 6 inches in diameter makes up 80 percent of the volume and obscures the structure; rapidly permeable; very strongly acid (pH 5.0); gradual boundary.

B2—30 to 48 inches +, reddish-yellow (7.5YR 6/6, dry) very cherty light silty clay loam, strong brown (7.5YR 5/6, moist); chert up to 8 inches in diameter makes up 80 percent of the volume and obscures the structure; rapidly permeable; very strongly acid (pH 5.0).

Stones cover from 20 percent to all the surface of the areas. The B1 and B2 horizons combined are 26 inches to 10 feet or more thick. Slopes range from 12 to 50 percent.

In some places the B horizons are redder than in the representative profile described. There are beds of tripoli in some places at a depth of 40 inches or more.

CHOTEAU SERIES

The Choteau series consists of deep, strongly acid, nearly level or gently sloping, well-drained soils on uplands. Most of the areas are in the valleys between Miami and Wyandotte. These soils are in the Brunizem great soil group. They formed under tall grass in old alluvium.

The Choteau soils are associated with soils of the Dennis series. Unlike those soils, which formed in material from shale, they have a light-colored A2 horizon. Furthermore, depth to the B horizon is greater. Choteau soils are also associated with the Parsons and Taloka soils, which are Planosols.

Representative profile of Choteau silt loam, 0 to 1 percent slopes, in a cultivated field that has been limed (250 feet south of the northeast corner of sec. 1, T. 26 N., R. 22 E.):

A1—0 to 12 inches, grayish-brown (10YR 5/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); moderate, medium, granular structure; friable; moderately permeable; neutral (pH 6.8); clear boundary.

A2—12 to 22 inches, pale-brown (10YR 6/3, dry) silt loam, brown (10YR 5/3, moist); weak, fine, granular structure; friable; moderately permeable; strongly acid (pH 5.2); gradual boundary.

AB—22 to 28 inches, light yellowish-brown (10YR 6/4, dry) light silty clay loam, yellowish brown (10YR 5/4, moist); a few, fine mottles of yellowish brown and yellowish red; a few chert fragments; weak, fine, blocky structure; friable; moderately permeable; strongly acid (pH 5.2); gradual boundary.

B2—28 to 35 inches, yellowish-brown (10YR 5/6, dry) silty clay loam, dark yellowish brown (10YR 4/6, moist); many, medium, distinct mottles of yellowish red and grayish brown; weak, medium, blocky structure; firm when moist, slightly hard when dry; slowly permeable; strongly acid (pH 5.2); gradual boundary.

B3—35 to 40 inches, brownish-yellow (10YR 6/8, dry) light silty clay loam, yellowish brown (10YR 5/8, moist); common, medium, faint mottles of pale brown; nearly structureless; firm when moist, slightly hard when dry; slowly permeable; a few manganese concretions and chert pebbles; strongly acid (pH 5.5); gradual boundary.

C—40 to 46 inches +, yellowish-brown (10YR 5/4, dry) light silty clay loam, dark yellowish brown (10YR 4/4, moist); many, coarse, distinct mottles of light gray and dark brown; contains manganese concretions and chert fragments; mildly alkaline (pH 7.5).

The A1 horizon ranges from grayish brown to dark brown in color and from 10 to 16 inches in thickness. Mottling varies. The texture of the B2 and B3 horizons

ranges from light clay loam to silty clay loam. Depth to the B2 horizon ranges from 24 to 32 inches.

The slope is 1 to 3 percent in about 54 percent of the acreage, but it is less than 1 percent in the rest of the acreage. Runoff is slow on the nearly level soils and medium on the gently sloping ones.

COLLINSVILLE SERIES

In the Collinsville series are very shallow, medium-textured, droughty, moderately sloping to steep soils of the uplands. These soils are excessively drained and only weakly developed. They occupy small areas on narrow ridges and steep breaks, mostly south and west of Miami. Collinsville soils are in the Lithosol great soil group. They are forming under tall grass in material weathered from sandstone of Pennsylvanian age. Generally, there are pieces of sandstone on the surface of the soils.

The soils are associated with soils of the Bates and Dennis series. They are not so deep as those soils, and, unlike those soils, lack a B horizon.

Representative profile of a Collinsville soil in a native meadow on a slope of 12 percent (1,500 feet south of the northwest corner of sec. 4, T. 26 N., R. 22 E.):

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2, dry) loam, very dark brown (10YR 2/2, moist); numerous sandstone fragments; moderate, medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); abrupt boundary.

Dr—7 inches +, bedrock of brown sandstone.

The A1 horizon varies in texture and ranges from 2 to 15 inches in thickness. Depth to the underlying sandstone is 2 to 15 inches.

In some places there are no stones on the surface, and in others 20 percent of the surface has a cover of stones.

CRAIG SERIES

The Craig series consists of moderately deep, gently or moderately sloping soils that are well drained. Most areas of these soils are small and are in prairie openings east of the Spring River or in a strip that extends across the county from north to south along the west side of the river. These soils are in the Brunizem great soil group. They formed under tall grass in residuum from cherty limestone of the Boone formation of Mississippian age.

Craig soils are associated with Dennis, Eldorado, and Parsons soils. They are redder than the Dennis soils, which formed from shale, and, unlike those soils, they have a cherty subsoil. They are deeper and have thicker horizons than the Eldorado soils, which are generally stony.

Representative profile of Craig silt loam, 3 to 5 percent slopes (800 feet north of the southwest corner of sec. 26, T. 26 N., R. 23 E.):

A11—0 to 8 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); moderate, medium, granular structure; friable; moderately permeable; a few chert pebbles; medium acid (pH 6.0); gradual boundary.

A12—8 to 16 inches, brown (10YR 5/3, dry) silt loam, dark brown (10YR 3/3, moist); moderate, medium, granular structure; friable; moderately permeable; a few chert fragments; medium acid (pH 5.8); gradual boundary.

B21—16 to 22 inches, brown (7.5YR 5/4, dry) light silty clay loam, dark brown (7.5YR 4/2, moist); a few, fine, faint mottles of grayish brown; weak, fine, subangular blocky structure; porous; friable; moderately permeable; a few chert fragments; medium acid (pH 5.8); gradual boundary.

B22—22 to 26 inches, reddish-brown (5YR 4/4, dry) gravelly clay loam, dark reddish brown (5YR 3/4, moist); a few, fine, distinct mottles of red; weak, fine, subangular blocky structure; firm when moist, slightly hard when dry; friable; porous; moderately permeable; chert from 1 to 4 inches in diameter makes up 40 percent of the volume; medium acid (pH 5.8); gradual boundary.

C—26 to 30 inches +, reddish-brown (5YR 5/4, dry) light silty clay loam, (5YR 4/4, moist); about 90 percent of the volume of this layer consists of chert; the fine material is very strongly acid (pH 5.0).

The color of the A11 horizon ranges from grayish brown to dark brown. Thickness of the combined A11 and A12 horizons ranges from 10 to 18 inches. Texture of the B22 horizon ranges from gravelly clay loam to gravelly silty clay. Depth to the B22 horizon ranges from 15 to 25 inches.

DENNIS SERIES

In the Dennis series are deep, medium-textured, nearly level to moderately sloping, well-drained soils on uplands. These soils occur throughout the western part of the county and are the most extensive soils in that area. They are in the Brunizem great soil group. Dennis soils formed under tall grass in material weathered from sandy and clayey shale of Pennsylvanian age.

These soils are associated with the Bates soils, but they are finer textured throughout the profile and have finer textured parent material. They are also associated with the Parsons and Taloka soils, which are Planosols.

Representative profile of Dennis silt loam, 1 to 3 percent slopes, in a pasture of native grass (3,200 feet south of the northeast corner of sec. 14, T. 27 N., R. 22 E.):

A1—0 to 14 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); moderate, medium, granular structure; friable; moderately permeable; strongly acid (pH 5.5); clear boundary.

B1 14 to 18 inches, brown (10YR 5/3, dry) light silty clay loam, dark brown (10YR 4/3, moist); moderate, medium, granular structure; friable; moderately permeable; very strongly acid (pH 5.0); gradual boundary.

B2—18 to 29 inches, pale-brown (10YR 6/3, dry) clay loam, brown (10YR 5/3, moist); many, fine, distinct mottles of yellowish red; strong, medium, blocky structure; firm when moist, hard when dry; clay skins are evident; slowly permeable; very strongly acid (pH 5.0); gradual boundary.

C—29 to 42 inches +, brownish-yellow (10YR 6/8, dry) heavy clay loam, yellowish brown (10YR 5/8, moist); many, common, prominent mottles of light gray; medium acid (pH 6.0).

The A1 horizon ranges from grayish brown to dark grayish brown in color. It ranges from 10 to 16 inches in thickness but averages about 12 inches. The B2 horizon ranges from brown to yellowish brown in color and from medium clay loam to light clay in texture.

In about 90 percent of the acreage, the slope ranges from 1 to 3 percent. Drainage is slower where the slope is 0 to 1 percent than where the slope is stronger, but it is adequate.

ELDORADO SERIES

The Eldorado series consists of gently sloping to strongly sloping, well-drained or somewhat excessively drained soils on uplands. These soils occupy small areas on narrow ridges and breaks, mostly on the west side of the Spring

River in a strip that runs north and south across the county. Other areas are in prairie openings east of that river. Eldorado soils are in the Reddish Prairie great soil group. They are forming under tall grass in material weathered from cherty limestone of Mississippian age. They are weakly developed, are droughty, and have cherty gravel or stones on the surface.

Representative profile of an Eldorado soil in a native meadow on a 2 percent slope (200 feet east of the northwest corner of sec. 10, T. 28 N., R. 24 E.):

A1—0 to 8 inches, dark grayish-brown (10YR 4/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); a few chert fragments; strong, medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); gradual boundary.

A3—8 to 14 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); chert fragments make up 5 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; strongly acid (pH 5.5); clear, wavy boundary.

B2—14 to 24 inches, pale-brown (10YR 6/3, dry) very cherty light clay loam, brown (10YR 5/3, moist); many, coarse, distinct mottles of red and gray; chert from 1 to 3 inches in diameter makes up 75 percent of the volume; moderately rapid permeability; very strongly acid (pH 5.0); abrupt boundary.

D—24 to 36 inches +, interbedded fragments and ledges of chert.

The A1 horizon ranges from dark grayish brown to black in color, from silt loam to stony silt loam in texture, and from 2 to 14 inches in thickness. The B2 horizon ranges from very cherty light clay loam to very cherty heavy silty clay loam.

Runoff is rapid. In places there are no stones on the surface, but in other places 40 percent of the surface has a cover of stones.

ETOWAH SERIES

In the Etowah series are deep, medium-textured nearly level to strongly sloping, well-drained soils. These moderately productive soils are on stream terraces along the Spring River and its tributaries. They belong to the Red-Yellow Podzolic great soil group. Etowah soils formed in old alluvium washed from cherty soils. The native vegetation was a hardwood forest with tall grass in the openings.

These soils are associated with Bodine soils on the slopes and with Huntington soils on the flood plains. In contrast to the Bodine soils, Etowah soils are less gravelly in the upper horizons, are more slowly permeable, and have more moisture-holding capacity. They are redder than the Huntington soils.

Representative profile of Etowah silt loam, 0 to 3 percent slopes, in a nearly level, cultivated field (500 feet south and 300 feet east of the northwest corner of sec. 32, T. 28 N., R. 24 E.):

Alp—0 to 6 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); about 5 percent of the volume is waterworn chert gravel; weak, fine, granular structure; very friable; moderately permeable; strongly acid (pH 5.2); clear boundary.

A1—6 to 14 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); about 5 percent of the volume is waterworn chert gravel; weak, fine, granular structure; moderately permeable, strongly acid (pH 5.2); gradual boundary.

B21—14 to 25 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) light clay loam; about 5 percent of the volume is waterworn chert gravel; moderate, medium, granular structure; friable; moderately permeable; strongly acid (pH 5.5); gradual boundary.

B22—25 to 40 inches, yellowish-red (5YR 5/6, dry; 4/6 moist) very gravelly clay loam; structure is obscured by gravel; moderately rapid permeability; strongly acid (pH 5.5); gradual boundary.

C—40 to 72 inches +, reddish-yellow (7.5YR 7/6, dry) very gravelly clay loam, strong brown (7.5YR 5/6, moist).

The surface layer is silt loam or gravelly silt loam. The A1 horizon ranges from brown to grayish brown in color and from 9 to 16 inches in thickness. Texture of the B21 and B22 horizons ranges from light silty clay loam to very gravelly clay loam.

The amount of chert in the profile varies. In places the profile is nearly free of gravel to a depth of about 26 inches. The surface layer of the gravelly silt loam contains gravel and, in many places, chert washed from the Bodine soils.

HUNTINGTON SERIES

In the Huntington series are deep, nearly level, well-drained soils that have a gravelly C horizon. These soils are on flood plains of the Spring River and its tributaries. They are in the Alluvial great soil group. Huntington soils are forming under hardwood trees in recent alluvium washed from cherty soils.

The surface layer is silt loam or gravelly silt loam. Generally, the silt loam is along the larger streams and the gravelly silt loam is along the smaller streams. Huntington soils are flooded one to three times each year and receive fresh deposits of soil, but the floodwater causes little damage.

These soils are associated with the Etowah and Bodine soils. In contrast to the Etowah soils, they lack a textural B horizon and have a less red subsoil.

Representative profile of Huntington gravelly silt loam in a cultivated field (1,320 feet east of the southwest corner of sec. 28, T. 27 N., R. 24 E.):

A1—0 to 11 inches, dark grayish-brown (10YR 4/2, dry) gravelly silt loam, very dark grayish brown (10YR 3/2, moist); gravel makes up 40 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); gradual, wavy boundary.

C—11 to 50 inches +, brown (10YR 5/3, dry) gravelly silty clay loam, dark brown (10YR 4/3, moist); gravel makes up 45 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; strongly acid (pH 5.5).

The A1 horizon is dark grayish brown or grayish brown. It ranges from 10 to 20 inches in thickness. Gravel makes up 10 to 40 percent of the volume of the A1 horizon. In places there is an AC horizon.

Representative profile of Huntington silt loam, in a cultivated field (2,600 feet north and 300 feet west of the southeast corner of sec. 35, T. 27 N., R. 24 E.):

A1—0 to 12 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); chert gravel makes up 5 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); gradual boundary.

AC—12 to 28 inches, dark grayish-brown (10YR 4/2, dry) light silty clay loam, very dark grayish-brown (10YR 3/2, moist); chert gravel makes up 5 to 8 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; slightly acid (pH 6.5); gradual, wavy boundary.

C—28 to 64 inches +, dark grayish-brown (10YR 4/2, dry) very gravelly silty clay loam, very dark grayish brown (10YR 3/2, moist); gravel makes up 80 percent of the volume; moderately permeable; neutral (pH 7.0).

The A1 horizon is grayish brown or dark grayish brown. It ranges from 10 to 28 inches in thickness. The C horizon ranges from dark grayish brown to brown. It consists of gravelly or very gravelly light clay loam or silty clay loam. The AC horizon is lacking in places.

Runoff is medium. Permeability of the subsoil is moderate or moderately rapid.

KAW SERIES

In the Kaw series are deep, moderately fine textured, nearly level, well drained or moderately well drained soils on flood plains. The areas are along some of the smaller streams east of Miami. These soils are in the Alluvial great soil group. They are forming in recent alluvium washed from prairie soils. The native vegetation was mainly tall grass, but there were some lowland hardwoods.

Areas of Kaw soils are flooded about once each year, but the water seldom causes damage, since the floodwater recedes rapidly after a rain.

Kaw soils are near the Bates, Dennis, Woodson, and Verdigris soils. They are similar to the Verdigris soils, but they are darker colored and have slower permeability.

Representative profile of Kaw clay loam in a native pasture (600 feet south of the northeast corner of sec. 28, T. 28 N., R. 23 E.):

A1—0 to 29 inches, dark-gray (10YR 4/1, dry) clay loam, black (10YR 2/1, moist); strong, medium, granular structure; friable; moderately permeable; a few, small, rounded chert pebbles in the lower 10 inches of this horizon; slightly acid (pH 6.3); gradual boundary.

C—29 to 50 inches +, dark grayish-brown (10YR 4/2, dry) clay loam, very dark grayish brown (10YR 3/2, moist); a few, fine, faint mottles of dark yellowish-brown; strong, medium, granular structure; friable; slowly permeable; a few rounded chert pebbles; medium acid (pH 6.0).

The surface layer ranges from 15 to 30 inches in thickness. Texture of the C horizon is clay loam or silty clay loam.

LAWRENCE SERIES

The Lawrence series consists of deep, nearly level, somewhat poorly drained soils of the uplands. These soils are on the Ozark Plateau in the eastern part of the county, mostly east of the Spring River. They are in the Planosol great soil group. Lawrence soils formed in material weathered from cherty limestone of the Boone formation of Mississippian age. The native vegetation was a forest made up mainly of oak, but it included other hardwoods.

These soils have a thin organic-mineral A1 horizon. Below is a thick, light-colored A2 horizon.

Lawrence soils are associated with the Bodine and Baxter soils, but they are not so well drained as those soils.

Representative profile of Lawrence silt loam in an undisturbed area (4,600 feet south of State Highway No. 10C along the border between Oklahoma and Missouri):

A1—0 to 4 inches, light brownish-gray (10YR 6/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); weak, fine, granular structure; very friable; moderately permeable; slightly acid (pH 6.5); gradual boundary.

A2—4 to 12 inches, very pale brown (10YR 7/3, dry) silt loam, yellowish brown (10YR 5/4, moist); weak, fine, granular structure; very friable; moderately permeable; a few chert pebbles; medium acid (pH 5.8); clear boundary.

B21—12 to 20 inches, yellowish-brown (10YR 5/4, dry) heavy silty clay loam, dark yellowish brown (10YR 4/4, moist); many, coarse, distinct mottles of red, brown, and gray; strong, medium, blocky structure; firm when moist, hard when dry; very slowly permeable; a few chert pebbles; very strongly acid (pH 4.5); gradual boundary.

B22—20 to 28 inches, grayish-brown (10YR 5/2, dry) silty clay loam, dark grayish brown (10YR 4/2, moist); many, coarse, distinct mottles of red, yellowish brown, and gray; strong, medium, blocky structure; very firm when moist, very hard when dry; very slowly permeable; a few chert pebbles that increase in number with increasing depth; very strongly acid (pH 4.5); gradual boundary.

B3—28 to 33 inches, light brownish-gray (10YR 6/2, dry) silty clay loam, grayish brown (10YR 5/2, moist); many, coarse, faint mottles of yellowish brown and brown; strong, medium, blocky structure; very firm when moist, very hard when dry; chert gravel makes up 30 percent of the volume; very strongly acid (pH 4.5); gradual boundary.

C—33 to 36 inches +, light silty clay loam between crevices of chert, which makes up 98 percent of the volume.

The A1 horizon is brownish gray or light brownish gray. The thickness of the A1 and A2 horizons combined ranges from 10 to 18 inches. The B22 and B3 horizons range from medium to heavy silty clay loam in texture and have minor variations in color and in chert content.

LIGHTNING SERIES

In the Lightning series are deep, nearly level, somewhat poorly drained soils that have a light-colored A2 horizon. These soils are in the flood plains of the Neosho River and its tributaries, mostly along the smaller streams. They are in the Planosol great soil group. Lightning soils formed in alluvium washed from prairie soils. The native vegetation was tall grass and scattered lowland hardwood trees.

These soils are associated with the Osage and Verdigris soils. They have a light-colored subsurface layer, which is lacking in Osage and Verdigris soils, and are lighter colored and more mottled than those soils. Lightning soils have less clay throughout the profile than the Osage soils and are less well drained and more mottled than Verdigris soils.

Representative profile of Lightning silt loam in a nearly level, cultivated field (center of sec. 30, T. 29 N., R. 22 E.):

A1—0 to 9 inches, light brownish-gray (10YR 6/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); weak, fine, granular structure; friable; moderately permeable; slightly acid (pH 6.5); gradual boundary.

A2—9 to 18 inches, light-gray (10YR 7/2, dry) silt loam, grayish brown (10YR 5/2, moist); a few, medium, faint mottles of dark yellowish brown; moderate, medium, granular structure; friable; porous; moderately permeable; a few black concretions; very strongly acid (pH 5.0); abrupt boundary.

B2—18 to 34 inches, dark grayish-brown (10YR 4/2, dry) silty clay, very dark grayish brown (10YR 3/2, moist); common, medium, faint mottles of dark yellowish brown; moderate, medium, blocky structure; firm when moist, hard when dry; very slowly permeable; very strongly acid (pH 5.0); gradual boundary.

C—34 to 60 inches +, light brownish-gray (10YR 6/2, dry) silty clay, gray (10YR 5/1, moist); many, coarse, faint mottles of yellowish brown; massive; very porous; very slowly permeable; very strongly acid (pH 5.0).

The texture of the A1 horizon ranges from silt loam to silty clay loam, and the thickness ranges from 7 to 14

inches. The texture of the B2 horizon ranges from clay loam to heavy silty clay.

NEWTONIA SERIES

The soils of the Newtonia series are deep, medium textured, gently sloping or moderately sloping, and well drained. They occupy small areas, mostly near Fairland.

These soils are in the Reddish Prairie great soil group. They formed under tall grass in material weathered from limestone that contained some chert. These soils are productive. Most of the alfalfa grown in the county is grown on them.

Newtonia soils are associated with the Dennis and Summit soils. They are lighter colored than the Summit soils and have a redder, less clayey, and more permeable subsoil. The Newtonia soils are also associated with the Sogn soils, which are Lithosols.

Representative profile of Newtonia silt loam, 1 to 3 percent slopes, in a cultivated field (2,600 feet south of the northwest corner of sec. 20, T. 27 N., R. 23 E.):

A1p—0 to 7 inches, brown (7.5YR 5/4, dry) silt loam, dark brown (7.5YR 3/4, moist); weak, medium, granular structure; friable; moderately permeable; strongly acid (pH 5.5); clear boundary.

A1—7 to 16 inches, brown (7.5YR 5/4, dry) silt loam, dark brown (7.5YR 3/4, moist); moderate, medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); clear boundary.

B21—16 to 30 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) light silty clay loam; moderate, medium to strong, granular structure; friable; moderately permeable; medium acid (pH 6.0); gradual boundary.

B22—30 to 56 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) silty clay loam; moderate, medium to strong, granular structure; friable; moderately permeable; medium acid (pH 5.8); gradual boundary.

C—56 to 64 inches, red (2.5YR 4/6, dry) silty clay loam, dark red (2.5YR 3/6, moist); massive; a few chert fragments.

Cu—64 to 70 inches +, material is similar to that in the C horizon but contains numerous chert fragments.

The color of the A1 horizon ranges from pale brown to reddish brown, and the thickness ranges from 12 to 18 inches. The texture of the B21 and B22 horizons ranges from silty clay loam to clay loam, and the color ranges from brown to reddish yellow or yellowish red. Depth to the C horizon ranges from 30 to 80 inches. In places the C horizon is lacking and there is a Dr horizon at that depth.

OSAGE SERIES

In the Osage series, are deep, fine-textured, nearly level, somewhat poorly drained soils on flood plains. These soils are along the Neosho River and its tributaries. They are in the Alluvial great soil group. Osage soils formed in recent alluvium washed from prairie soils. The native vegetation was tall grass and scattered hardwood trees.

These soils are associated with soils of the Verdigris and Lightning series but are darker colored than those soils. Osage soils are less well drained than the Verdigris soils. They are less mottled than the Lightning soils, which are Planosols.

Representative profile of Osage silty clay in a native meadow (2,600 feet south and 300 feet west of the northeast corner of sec. 7, T. 28 N., R. 22 E.):

A11—0 to 6 inches, very dark gray (10YR 3/1, dry) silty clay, black (10YR 2/1, moist); strong, coarse, granular structure; friable; slowly permeable; medium acid (6.0); gradual boundary.

A12—6 to 13 inches, dark-gray (5Y 4/1, dry) clay, black (5Y 2/1, moist); strong, coarse, granular structure; slowly permeable; mildly alkaline (pH 7.5); gradual boundary.

AC1—13 to 20 inches, dark-gray (5Y 4/1, dry) clay, black (5Y 2/1, moist); moderate, coarse to medium, blocky structure; very firm when moist, very hard when dry; clay films on the surface of the peds; medium acid (pH 6.0); gradual boundary.

AC2—20 to 32 inches, olive-gray (5Y 5/2, dry) clay, dark olive gray (5Y 3/2, moist); common, fine, distinct mottles of olive brown; weak, medium to coarse, blocky structure; very firm when moist, very hard when dry; clay films on the surfaces of the peds; many concretions of manganese; strongly acid (pH 5.5); gradual boundary.

C—32 to 60 inches +, gray (5Y 6/1, dry), silty clay or clay, dark gray (5Y 4/1, moist); many, medium, distinct mottles of olive brown; weak, medium, blocky structure above a depth of 44 inches, but massive below that depth; very firm when moist, very hard when dry; there are slickensides in the lower part of the horizon; contains black concretions in places.

The texture of the A11 and A21 horizons ranges from clay to heavy silty clay. The C horizon is heavy silty clay, heavy clay loam, or clay and has minor variations in color and in mottling.

PARSONS SERIES

The Parsons series consists of deep, medium-textured, nearly level to gently sloping, somewhat poorly drained soils on uplands. The areas are on broad flats and gentle slopes in the central and western parts of the county. Parsons soils are in the Planosol great soil group. They formed under tall grass in material weathered from clayey shale of Pennsylvanian age.

These soils have a light-colored A2 horizon. Their B horizon is heavy, blocky, mottled clay.

Parsons soils are associated with soils of the Bates, Dennis, and Taloka series. They are similar to the Taloka soils, but they are less deep to the claypan than those soils, which formed in old alluvium.

Profile of Parsons silt loam, 0 to 1 percent slopes, in a field that formerly was cultivated (1,000 feet north and 1,200 feet west of the southeast corner of sec. 25, T. 27 N., R. 22 E.):

A1p—0 to 6 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); weak, fine, granular structure; friable; moderately permeable; very strongly acid (pH 5.0); clear boundary.

A1—6 to 12 inches, light brownish-gray (10YR 6/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); moderate, fine, granular structure; friable; moderately permeable; strongly acid (pH 5.5); clear boundary.

A2—12 to 15 inches, light-gray (10YR 7/2, dry) silt loam, grayish brown (10YR 5/2, moist); common, fine, faint mottles of strong brown; structureless; abrupt boundary.

B21—15 to 30 inches, dark grayish-brown (10YR 4/2, dry) clay, very dark grayish brown (10YR 3/2, moist); many, medium, faint mottles of dark brown; moderate, coarse, blocky structure; very firm when moist, very hard when dry; very slowly permeable; clay films prominent; medium acid (pH 6.0); gradual boundary.

B22—30 to 38 inches, yellowish-brown (10YR 5/4, dry) clay, dark yellowish brown (10YR 4/4, moist); common, medium, faint mottles of grayish brown; very firm when moist, very hard when dry; slightly acid (pH 6.5); gradual boundary.

C—38 to 46 inches +, light brownish-gray (10YR 6/2, dry) clay, grayish brown (10YR 5/2, moist); many, medium and coarse, faint mottles of dark yellowish brown and gray; numerous black concretions and gypsum crystals; massive; neutral (pH 7.0).

The thickness of the A1 horizon is 8 to 12 inches, and the color ranges from grayish brown to dark grayish brown. The mottles vary in color, and some of them are yellowish red rather than brownish. Depth to the claypan ranges from 8 to 16 inches.

Where the slope is 0 to 1 percent, runoff is slow, but where the slope is stronger or the soil is eroded, runoff is medium. The subsoil is very slowly permeable.

RIVERTON SERIES

In the Riverton series are deep, gravelly, moderately sloping soils that are well drained or somewhat excessively drained. These soils are on uplands in small areas west of the Spring River. They are in the Reddish Prairie great soil group. Riverton soils formed under tall grass in old alluvium washed from cherty soils. They are strongly acid or very strongly acid.

These soils are associated with soils of the Bates, Collinsville, and Dennis series. In contrast to those soils, they are gravelly in the A1 horizon and very gravelly in in the B and C horizons.

Representative profile of Riverton gravelly loam in a gravel pit (500 feet northeast of the southwest corner of sec. 36, T. 28 N., R. 23 E.):

A1—0 to 7 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) gravelly loam; weak, fine, granular structure; friable; moderately permeable; strongly acid (pH 5.5); gradual boundary.

B1—7 to 23 inches, brown (10YR 5/3, dry) very gravelly light clay loam, dark brown (10YR 4/3, moist); waterworn chert gravel up to 1 inch in diameter makes up about 60 percent of the volume and obscures the structure; moderately rapid permeability; strongly acid (pH 5.5); gradual boundary.

B2—23 to 39 inches, light redish-brown (5YR 6/4, dry) very gravelly clay loam, reddish brown (5YR 4/4, moist); same siftings of light-gray silt; waterworn gravel up to 2 inches in diameter makes up about 80 percent of the volume and obscures the structure; moderately rapid permeability; very strongly acid (pH 5.0); gradual boundary.

C—39 to 60 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) clay loam between waterworn pebbles that make up 90 percent of the volume; in the lower part of this horizon are stratified layers of gray clay about one-half inch thick; very strongly acid (pH 5.0).

The A1 horizon ranges from dark brown to dark grayish brown in color, from gravelly loam to gravelly silt loam in texture, and from 6 to 16 inches in thickness. The texture of the B1 and B2 horizons ranges from gravelly or very gravelly light clay loam to heavy silty clay loam. The amount of gravel in the B horizons ranges from about 30 to 85 percent.

SOGN SERIES

In the Sogn series are gently sloping to strongly sloping, well-drained soils on uplands. These soils are in small areas near Fairland. They belong to the Lithosol great soil group. Sogn soils are forming under mid grasses in material from limestone of Pennsylvanian age.

These soils are dark colored, moderately fine textured, and very shallow over limestone bedrock. Limestone is exposed in about 30 percent of the acreage.

Sogn soils are associated with the Newtonia, Summit, and Woodson soils, all of which are deeper than the Sogn soils.

Representative profile of a Sogn soil in an undisturbed area (1,320 feet south of the northwest corner of sec. 11, T. 26 N., R. 23 E.):

A11—0 to 6 inches, very dark gray (10YR 3/1, dry) clay loam, black (10YR 2/1, moist); moderate, medium, granular structure; friable; moderately permeable; neutral (pH 6.8); gradual boundary.

A12—6 to 10 inches, very dark grayish-brown (10YR 3/2, dry) silty clay loam, very dark brown (10YR 2/2, moist); limestone fragments make up 5 percent of the volume; moderate, medium, granular structure; friable; moderately permeable; abrupt boundary.

Dr—10 inches +, limestone bedrock.

The thickness of the A11 and A12 horizons combined ranges from 2 to 15 inches. Where the surface layer is thin, the A12 horizon is lacking. Limestone is exposed in 20 to 40 percent of the areas.

SUMMIT SERIES

The Summit series consists of deep, dark-colored, moderately fine textured, gently sloping soils that are well drained. These upland soils are generally on foot slopes near Fairland. They are in the Brunizem great soil group. Summit soils formed under tall grass in material weathered from limestone or soft calcareous shale of Pennsylvanian age.

These soils are associated with soils of the Dennis, Newtonia, and Woodson series. Their surface layer is more granular than that of the Woodson soils and their subsoil is less clayey and more permeable. The Summit soils are also near the Sogn soils, which are Lithosols.

Representative profile of Summit silty clay loam, 1 to 3 percent slopes, in a cultivated field (2,000 feet north of the southeast corner of sec. 29, T. 27 N., R. 23 E.):

Alp—0 to 7 inches, very dark gray (10YR 3/1, dry) medium silty clay loam, black (10YR 2/1, moist); moderate, medium, granular structure; friable; moderately permeable; slightly acid (pH 6.5); abrupt boundary.

A1—7 to 12 inches, very dark gray (10YR 3/1, dry) silty clay loam, black (10YR 2/1, moist); strong, medium, granular structure; friable; moderately permeable; slightly acid (pH 6.5); gradual boundary.

A3—12 to 20 inches, very dark gray (5Y 3/1, dry) heavy silty clay loam, black (5Y 2/1, moist); moderate, medium, granular structure; friable; slowly permeable; neutral (pH 6.9); gradual boundary.

B1—20 to 30 inches, dark-gray (5Y 4/1, dry) clay loam, very dark gray (5Y 3/1, moist); moderate, medium, blocky structure; firm when moist, slightly hard when dry; slowly permeable; neutral (pH 7.0); gradual boundary.

B2—30 to 42 inches, olive (5Y 5/3, dry; 4/3, moist) silty clay; common, fine, prominent mottles of light olive brown; moderate, medium, blocky structure; firm when moist, slightly hard when dry; slowly permeable; a few concretions of calcium and iron; mildly alkaline (pH 7.5); abrupt boundary.

D—42 inches +, calcareous shale.

The thickness of the surface layer ranges from 10 to 16 inches. The texture of the B2 horizon is silty clay or clay. Minor variations in color occur in the A and B horizons. Bedrock is calcareous shale or limestone. Depth to shale or limestone ranges from 30 to 48 inches but averages about 40. Runoff is medium.

TALOKA SERIES

In the Taloka series are deep, medium-textured, nearly level soils through which water moves slowly. These soils are on broad flats in the northern and western parts of the county. They are in the Planosol great soil group. Taloka soils formed under tall grass in old alluvium washed from soils of the prairies.

The A2 horizon of the Taloka soils is light colored. The subsoil is heavy, blocky, and mottled.

Taloka soils are associated with Bates, Choteau, Dennis and Parsons soils. They are similar to the Parsons soils, but depth to the claypan is greater than in those soils. Their subsoil is a heavier, more slowly permeable clay than that in the Choteau soils.

Representative profile of Taloka silt loam, 0 to 1 percent slopes, in a cultivated field (1,400 feet north of the southwest corner of sec. 10, T. 28 N., R. 23 E.):

A1p—0 to 5 inches, grayish-brown (10YR 5/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); weak, fine, granular structure; friable; moderately permeable; medium acid (pH 5.8); clear boundary.

A1—5 to 12 inches, grayish-brown (10YR 5/2, dry) silt loam, dark grayish brown (10YR 4/2, moist); weak, fine and and medium, granular structure; friable; moderately permeable; very strongly acid (pH 5.0); gradual boundary.

A2—12 to 20 inches, very pale brown (10YR 7/3, dry) silt loam, brown (10YR 5/3, moist); common, fine, faint mottles of yellowish brown; weak, fine, granular structure; friable; moderately permeable; very strongly acid (pH 5.0); abrupt boundary.

B21—20 to 30 inches, dark grayish-brown (10YR 4/2, dry) clay, very dark grayish brown (10YR 3/2, moist); many, medium, prominent mottles of dark brown and dark red; strong, medium, blocky structure; very firm when moist, very hard when dry; very slowly permeable; very strongly acid (pH 5.0); gradual boundary.

B22—30 to 36 inches, grayish-brown (10YR 5/2, dry) clay, dark grayish brown (10YR 4/2, moist); a few, fine, faint mottles of yellowish brown; massive; firm when moist, hard when dry; very slowly permeable; strongly acid (pH 5.5); gradual boundary.

B3—36 to 46 inches, light brownish-gray (10YR 6/2, dry) clay, grayish brown (10YR 5/2, moist); many, medium, faint mottles of yellowish brown; massive; firm when moist, hard when dry; very slowly permeable; medium acid (pH 6.0); gradual boundary.

C—46 to 56 inches +, light-gray (10YR 7/2, dry) silty clay, light brownish gray (10YR 6/2, moist); a few, medium, faint mottles of yellowish brown; massive; slightly acid (pH 6.5).

There are minor variations in color and mottling. Depth to the claypan ranges from 16 to 30 inches. Runoff is slow, and permeability of the subsoil is very slow.

VERDIGRIS SERIES

The Verdigris series consists of deep, nearly level, well drained or moderately well drained soils. These productive soils are on flood plains along the Neosho River and its tributaries. They are in the Alluvial great soil group. Verdigris soils are forming in recent alluvium washed from soils of the prairies. The native vegetation was tall grass and scattered lowland hardwoods.

These soils are associated with the Lightning and Osage soils. They are darker colored and less mottled than the Lightning soils, and they lack the A2 horizon, which is typical of those soils. They are lighter colored, coarser textured, and better drained than the Osage soils.

Profile of Verdigris silt loam in a cultivated field (2,700 feet south of the northwest corner of sec. 16, T. 28 N., R. 22 E.):

A1—0 to 11 inches, dark grayish-brown (10YR 4/2, dry) silt loam, very dark grayish brown (10YR 3/2, moist); weak, fine and medium, granular structure; friable; moderately permeable; medium acid (pH 6.0); clear boundary.

AC—11 to 25 inches, brown (10YR 5/3, dry) silt loam, dark brown (10YR 4/3, moist); weak, medium, granular structure to massive; porous; friable; moderately permeable; slightly acid (pH 6.5); gradual boundary.

C—25 to 60 inches +, pale-brown (10YR 6/3, dry) silt loam, dark brown (10YR 4/3, moist); somewhat stratified with layers of light clay loam; a few, fine, faint mottles of grayish brown and dark yellowish brown; friable; moderately permeable; medium acid (pH 6.0).

The color of the A1 horizon ranges from grayish brown to very dark grayish brown, and the thickness ranges from 6 to 20 inches. The texture is silt loam or clay loam. Texture of the C horizon ranges from silt loam to light clay loam.

WOODSON SERIES

The Woodson series consists of deep, dark-colored, moderately fine textured, nearly level or gently sloping soils that are moderately well drained to somewhat poorly drained. These soils are in wide, shallow drainageways and on flats, mostly in the southern part of the county. They are in the Brunizem great soil group. Woodson soils formed under tall grass in material weathered from clayey shale of Pennsylvanian age.

These soils are associated with the Dennis, Parsons, and Summit soils. Their surface layer is finer textured and darker colored than that of the Parsons soils, and they lack the light-colored subsurface layer typical of those soils. Their surface layer is less granular than that of the Summit soils, and their subsoil is more slowly permeable.

Representative profile of Woodson silty clay loam, 0 to 1 percent slopes, on the north side of U.S. Highway 60, in a cultivated field (1,320 feet south and 1,000 feet east of the northwest corner of sec. 17, T. 26 N., R. 23 E.):

A1—0 to 10 inches, black (N 2/0, dry and moist) silty clay loam; moderate, medium and fine, granular structure; slowly permeable; neutral (pH 7.0); clear boundary.

B2—10 to 22 inches, very dark gray (2.5Y 3/1, dry) clay, black (2.5Y 2/1, moist); moderate, fine, blocky structure; very firm when moist, very hard when dry; very slowly permeable; neutral (pH 7.0); gradual boundary.

C—22 to 60 inches +, dark-gray (N 4/0, dry) clay, very dark gray (N 3/0, moist); common, fine, faint mottles of light olive brown and brown; a few chert pebbles, calcium carbonate concretions, and gypsum crystals; massive; very firm when moist, very hard when dry; very slowly permeable; neutral (pH 7.2).

The A1 horizon ranges from 8 to 15 inches in thickness, but it averages about 12 inches. The B2 horizon is blocky in structure or is massive. Runoff is slow on the nearly level areas and medium on the sloping ones. Permeability of the subsoil is very slow.

General Nature of the County

In this section the geology, relief, and drainage and the climate of the county are discussed and facts are given about the water supply, vegetation, and history and development. Information is also given about the community life, the industry and transportation, and the agriculture of the county. The statistics are mainly from reports published by the U.S. Bureau of the Census.

Geology, Relief, and Drainage

Ottawa County is underlain by geologic formations of two ages. The western part is underlain by sandstone and shale of Pennsylvanian age, and the eastern part by cherty limestone of Mississippian age.

In the western part of the county, commonly called the Cherokee Prairies, the soils formed in materials largely from the McCallister and Savannah formations or in old alluvium. The dominant soils in this area are of the Bates, Choteau, Collinsville, Dennis, Lightning, Osage, Parsons, Taloka, Verdigris, and Woodson series.

The eastern part of the county is part of the Ozark Plateau. Forests, interspersed with areas of prairie grass, cover much of the acreage. The soils here formed in material from the Boone formation. They are mainly of the Baxter, Bodine, Craig, Eldorado, Etowah, and Huntington series.

Between the Cherokee Prairies and Ozark Plateau is an area where formations of the Pennsylvanian and Mississippian ages are intermixed. The rocks that underlie this area are of the formations already named and, in addition, of the Batesville, Fayetteville, and Morefield formations. In this area the soils are mainly of the Craig, Choteau, Dennis, Eldorado, Huntington, Newtonia, Parsons, Summit, Taloka, and Woodson series.

The relief of the county varies. The western part is a dissected plain and makes up two-thirds of the county. It is mostly gently rolling, but there are some broad, nearly level areas in the uplands. The eastern part of the county, which is gently rolling to steep, is an extension of the Ozark Plateau. It is made up of steep, hilly areas and of smooth areas on ridgetops.

The western part of the county is drained by the Neosho River, and the eastern part, by the Spring River. These rivers flow into the Lake of the Cherokees, which is in the east-central part of the county and extends through Delaware County to the south.

Climate [13]

Ottawa County has a temperate, continental climate characteristic of the southern prairie plains where they merge with the southwestern extension of the Ozark Plateau.

Changes between seasons are gradual, but the characteristics of the seasons are fairly well defined. The winter season ranges from cold to moderate; there are many sunny days between storms. Snow rarely covers the ground for more than 3 or 4 days at a time. Spring is the season when the weather is most variable and when the largest amount of rainfall of high intensity occurs. In May 1943, for example, 23.95 inches of rain fell, and 60 percent of it fell in 3 days. Summers are generally hot, but the nights are cool. In the fall there are long periods of pleasant days interspersed with spells of moderate to heavy rains.

The average annual temperature in the county is 60° F. Temperatures range on the average from 38° in January to 83° in July. The temperature fell to −25° in 1930, however, and rose to 116° in 1954.

During the last 30 years the annual precipitation in the county, based on records kept in Miami, was 41.22 inches. The amount of precipitation has ranged from as little as 27.64 inches to as much as 71.01 inches. The rainfall is distributed favorably throughout the growing season and is ample for the crops grown. About 31 percent of the precipitation comes in spring; 29 percent in summer; 26 percent in fall; and 14 percent in winter. Short, dry periods occur occasionally, but they seldom last long enough to cause failure of crops. Each year, hard rains generally cause flooding, damage to crops, and loss of soil through erosion.

Winds are generally from the south, but in midwinter northerly winds predominate. The annual evaporation from lakes is 48.3 inches, and about 73 percent of the evaporation occurs from May to October.

Damage to crops from hail is small in Ottawa County. Small grains are damaged most frequently, and nearly 90 percent of the damage is to the wheat crop.

The freeze-free season is generally adequate to permit crops to mature. In the western two-thirds of the county, there are 205 days when the temperature is above freezing, but in the eastern part of the county the freeze-free season lasts about 190 days.

The climate in Ottawa County is favorable to agriculture. Only occasionally does a heavy rain or snow slow farming operations. The average monthly temperatures and precipitation in spring and fall are generally favorable for preparing the soil, seeding the crop, and for the plants to grow and mature. Temperature and precipitation for the county are given in table 9. The data are from the U.S. Weather Bureau at Miami.

[13] By Stanley G. Holbrook, State climatologist, U.S. Weather Bureau.

Water Supply

In the prairie areas in the western part of the county, much of the water from wells contains sulfur and other minerals and is, therefore, undesirable for home use. Nevertheless, much of it is used. On some of the farms, filters have been installed in ponds to make the water suitable for use in the homes. The principal source of water for livestock in the prairie areas is surface water impounded by dams.

Good pond sites are scarce in the Ozark Plateau in the eastern part of the county. Many farms have cherty soils that do not hold water. Consequently, much of the water supply for these farms comes from wells or streams. The water from the wells is of good quality, but the supply is sometimes short. There are many spring-fed streams in the Ozark Plateau, and they provide a good supply of clear, cold water for livestock.

Little irrigating is done in the county. A good supply of water for irrigating is available to farms near Neosho River and the Lake of the Cherokees. This water is controlled by the Grand River Dam Authority and must be purchased. Water for irrigation can also be obtained from a few of the smaller streams if needed for special crops.

Vegetation

Tall prairie grasses cover much of the western two-thirds of Ottawa County. Trees grow only along the streams. Here bluestem, switchgrass, and Indiangrass are dominant on the uplands and eastern gamagrass and prairie cordgrass are common on the bottom lands. Elm, oak, hackberry, walnut, and pecan are the main trees. Many of the native pastures and meadows are in excellent condition, but weeds, blackberry vines, sumac, and persimmon trees are common in overgazed areas.

Table 9.—*Temperature and precipitation, Ottawa County, Okla.*

[Based on data from records kept at Miami, Ottawa County, Okla., for the years 1931–1960]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average monthly total	One year in 10 will have—		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
					Inches	*Inches*	*Inches*	*Number*	*Inches*
January	48	27	66	10	1.75	0.3	4.0	4	2
February	53	30	68	15	2.01	.9	3.3	2	3
March	61	37	78	20	2.83	.9	5.2	2	2
April	72	48	85	34	3.99	1.9	7.2	1	2
May	80	57	89	44	6.01	2.4	7.9		
June	89	66	100	54	5.19	1.5	8.8		
July	95	70	103	61	3.43	.3	6.3		
August	95	69	106	59	3.13	.6	6.2		
September	87	61	99	47	4.65	.3	11.4		
October	76	50	90	35	3.86	.8	6.8		
November	60	38	77	22	2.36	(1)	5.7	2	3
December	50	30	68	15	2.01	.7	3.6	2	2
Year	72	49	(2) 105	(3) 1	41.22	32.2	52.4	13	2

[1] Trace. [2] Average highest maximum. [3] Average lowest minimum.

Originally, the eastern part of the county had a cover of large trees, and tall grasses grew in the openings. The trees were mostly red, white, and black oaks. Cutting of the trees for lumber and railroad ties, overgrazing, and fire have eliminated most of the large trees. As a result, sprouts and brush have encroached and little grass remains.

When grazed intensively, bluestem and other native grasses decrease in vigor and are replaced by plants of less value. The soils in the native pastures become drier and less able to absorb moisture if they are trampled excessively and if surface litter is removed. Proper grazing is needed on the shallow, steep, clayey, and eroded soils to maintain enough vegetation to protect them. Pastures and meadows in good condition are a good source of seed for revegetation of eroded cropland.

History and Development [14]

Ottawa County was named for the Ottawa Indian tribe, but Miami, the county seat, was named for the Miami Indians. Congress passed a special act in 1891 authorizing the Secretary of the Interior to sell land on behalf of the Ottawa Indian tribe. Thus, the Miami town company was organized.

Though it was originally a cattle grazing area, development of the county was closely connected with the mining of lead and zinc, which began in 1907. A second period when settlement was active came in the mid-1940's. A large multiple-arch dam was completed on the Neosho River, south of Ottawa County, and produced abundant electrical power. As a result, a large tire and tube manufacturing plant and other industries were established in the county, and many people came to the area to work in the factories.

Agriculture is keeping pace with the growth of industry in the county. By the 1940's many of the farmers were interested in protecting their land through conserving soil and moisture. Consequently, the Ottawa County Soil Conservation District was organized in 1946. Technicians of the Soil Conservation Service were assigned to assist the District in 1947, and with their help, many farmers began to apply needed practices to their land. In addition, the Agricultural Stabilization and Conservation Service of the Federal Government has shared the cost of some practices needed to conserve soil and moisture. Today, the farms of the county yield many fine agricultural products.

Community Life

This county has many groups that work to improve the life of the community. In Miami are a little theater group, an association of writers, a music group, and many civic organizations. There is also a public library. In addition, several artists work in the county. Among the many different rural organizations are Home Demonstration Clubs and 4-H Clubs, which work under the guidance of the Extension Service, and also Future Farmers of America and Future Homemakers of America.

The county has many schools. In Miami there are several grade schools and high schools. The Northeastern Oklahoma A. and M. Junior College is also in that city. Outside of Miami are 10 rural grade schools

[14] By J. D. Blakemore, county agent, Extension Service, U.S. Department of Agriculture.

and 6 high schools. The high schools are in Quapaw, Picher-Cardin, Commerce, Afton, Fairland, and Wyandotte. The Seneca Indian School for underprivileged children is in the east-central part of the county near Wyandotte.

Churches are numerous throughout the county. Most of them are in or near the communities, and 14 denominations are represented.

Recreational facilities for the public are in all parts of the county. Most of them, however, are near the Lake of the Cherokees, which is also known as Grand Lake. The cities provide playgrounds for the children and picnic grounds for adults. Miami has a civic center where there are conference rooms, a sports arena, and recreational facilities for young people.

Industries and Transportation

Lead and zinc mining were the principal industries in the county until the early 1940's. Now the largest industry in the county is a tire and tube manufacturing company, which employs about 1,600 people. Other industries are engaged in manufacturing aluminum and fiberglass boats, marine supplies, work clothing, awnings, tents, mops, caskets, floral supplies, pottery, gasoline and water cans, airplane and auto parts, truck beds, air conditioners, and furnaces. In addition, there are two meat packing plants, a charcoal plant, an electronic metals plant, several steel fabricating plants, and a building stone industry. Also, the air condition and refrigeration division of a large company was moved to Miami in 1960.

Facilities for public transportation are provided by rail and bus lines. One railroad runs from Tulsa to Afton, where it divides. From Afton one branch of the railroad runs to Kansas City, Mo., and the other, to St. Louis, Mo. Another railway, which connects Texas with Kansas, crosses the county from south to north. A local railroad serves the mining areas in northeastern Oklahoma and southeastern Kansas. There is regular bus service from Tulsa, Okla., to Joplin, Mo., and to other large cities.

Four Federal highways and several State highways serve the county. Roads in farm areas are generally good. Most of them are gravelled and are only rarely impassable. In the prairie areas in the western part of the county, most of the roads are laid along section lines. In the Ozark Plateau in the eastern part of the county, however, many of the roads follow the crooked valleys between the hills and cross the hills to other valleys. When the dogwoods are blooming and when the oak, maple, and hickory trees have taken on their fall colors, many people travel these roads to enjoy the scenery.

Agriculture

When Ottawa County was founded, tall grasses covered the area. In the early years after the county was settled, cultivated crops were grown continuously on most of the farms. Legumes were not used extensively, only a small amount of fertilizer was used, and little effort was made to improve the soils or to protect them from erosion. Pastures were generally overgrazed. Because of these farming practices, many of the soils became eroded and their supplies of plant nutrients were depleted.

The use of the soils has changed in the past 20 years, partly because of necessity and partly by choice. The acreage in small grains, tame pasture crops, and soybeans has increased and that in corn has decreased. Table 10 gives the acreage of the principal crops grown in the county in stated years.

TABLE 10.—*Acreage of principal crops*

Crops	1949	1954	1959
Corn for all purposes	20, 881	5, 740	9, 863
Sorghum for all purposes, except sirup	4, 100	6, 968	6, 660
Wheat harvested	22, 341	20, 018	25, 158
Oats harvested	10, 624	13, 483	10, 089
Barley harvested	742	5, 016	4, 132
Soybeans for all purposes	6, 099	9, 104	16, 121
Hay crops, total	19, 966	17, 461	16, 599
Alfalfa and alfalfa mixtures cut for hay	235	182	181
Lespedeza cut for hay	5, 170	462	2, 562
Small grains cut for hay	704	3, 405	800
Wild hay cut	12, 918	12, 675	12, 569
Other hay cut	939	737	487

Bermudagrass, fescue, lespedeza, and other perennial tame pasture crops are now grown on about 35,000 acres, most of which formerly were cultivated. These crops are generally overseeded with legumes or other plants. On much of the acreage, the tame pasture crops are grown in rotation with small grain used as a cash crop. The tame pastures carry more livestock than overgrazed, native pastures and yield better. Improved varieties of plants are selected on many of the farms and grown on soils that are best suited to the particular crop. Because of better management, including use of fertilizer, many grasses once considered unpalatable are now ranked among the better grasses.

Limestone has been applied on most of the soils to correct acidity. In 1959, 4,485 tons of commercial fertilizers were used on the crops grown in the county. But this amount of fertilizer is less than should be used to get best returns.

Improvements in cropping systems, use of improved varieties of small grains and other crops, growing crops on suitable soils, increased use of fertilizer, and other good farming practices have helped to increase yields. For example, since the late 1930's, the annual per acre yield of corn grown in the county increased from 16 bushels to 31 bushels. Yields of oats, wheat, and grain sorghum also increased.

Terraces have been built on many of the farms to help control erosion, but much more terracing is needed.

In 1959, there were 1,198 farms in the county, as compared to 1,688 farms in 1950. Of these, 605 were miscellaneous or unclassified. The rest are listed according to the major source of income as follows:

Farms:	*Number*
Cash grain	151
Dairy	175
Poultry	10
Livestock farms other than dairy and poultry	179
Vegetable	5
Fruit-and-nut	6
General	67

Livestock and livestock products provide a large part of the farm income in Ottawa County. Most of this income is derived from the sale of grazing animals, mainly beef and dairy cattle. The number of cattle has fluctuated according to the demand, but the trend has been upward. Purebred livestock make up many of the beef herds. The number and kinds of livestock in the county in stated years are shown in table 11.

TABLE 11.—*Number and kinds of livestock on the farms*

Livestock	1940	1950	1954	1959
Cattle and calves	[1] 16, 820	24, 307	28, 231	28, 474
Horses and mules	[1] 4, 738	2, 625	962	1, 315
Hogs and pigs	[2] 11, 734	12, 689	5, 806	8, 226
Sheep and lambs	[3] 1, 748	843	1, 124	1, 207
Chickens	[2] 114, 720	[2] 95, 538	[2] 68, 518	[2] 48, 573

[1] More than 3 months old.
[2] More than 4 months old.
[3] More than 6 months old.

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil materials, such as gravel, sand, silt, or clay deposited on land by streams.

Animal unit. In western range or pasture management, an animal unit is one cow, one horse, one mule, or five sheep, or five goats.

Animal-unit month. The amount of forage or feed needed to keep one animal unit in good condition for 30 days.

Base course, engineering. In road construction, selected material of planned thickness used as a foundation for pavement.

Blanket, engineering. A thin layer of clayey soil or other slowly permeable material placed on the upstream floor of an embankment to retard the seepage of water.

Calcareous soil. A soil containing enough calcium carbonate to effervesce (fizz) when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter (0.000079 inch) in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry or plastic and stiff when wet.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose. Noncoherent; will not hold together in a mass.

Friable. When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump. Friable soils are easily tilled.

Firm. When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable. Firm soils are likely to be difficult to till.

Hard. When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Plastic When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger. Plastic soils are high in clay and are difficult to till.

Sticky. When wet, adheres to other material; tends to stretch somewhat and pull apart, rather than pull free from other material.

Soft. When dry, breaks into powder or individual grains under slight pressure.

Cemented. Hard and brittle; little affected by moistening.

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to the terrace grade.

Cover crop. A close-growing crop grown primarily to protect and improve the soil between periods of regular crop production.

Diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Forb. Any herbaceous plant that is neither a grass nor a sedge.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, and covered by grass for protection against erosion; used to carry surface water away from cropland.

Grazing capacity. The maximum number of animals or animal units per acre, or acres per animal unit, that a grazing area can support adequately without deterioration; sometimes called carrying capacity.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. The relative position of the several soil horizons in a typical profile, and their nomenclature, are as follows:

A horizon. The master horizon consisting of (1) one or more mineral horizons in which there has been maximum accumulation of organic material; or (2) the surface or subsurface horizons that are lighter in color than the underlying horizon and have lost clay minerals, iron, and aluminum, with resultant concentration of the more resistant minerals; or (3) horizons belonging to both of these categories.

B horizon. The master horizon of altered material characterized by (1) an accumulation of clay, iron, or aluminum ,with accessory organic material; or (2) blocky or prismatic structure together with other characteristics, such as stronger colors, unlike those of the A horizons or the underlying horizons of nearly unchanged material; or (3) characteristics of both of these categories. Commonly, the lower limit of the B horizon corresponds to the lower limit of the solum.

C horizon. A layer of unconsolidated material, relatively little affected by organisms and presumed to be similar in chemical, physical, and mineralogical composition to the material from which at least a part of the solum has developed.

D horizon. Any stratum underlying the C horizon, or the B if no C is present, which is unlike the C horizon or unlike the material from which the solum has been formed.

Humus. The well-decomposed more or less stable part of the organic matter in mineral soils.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage.

Munsell notation. A system for designating color by degrees of the three variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Parent material. The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Permeability. The quality of a soil horizon that enables water or air to move through it.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Range. Land that, for the most part, produces native plants suitable for grazing by livestock.

Range site. An area of range where climate, soil, and topography are sufficiently uniform to produce a distinct kind of climax vegetation.

Reaction, soil. The degree of acidity or alkalinity of a soil mass, expressed either in pH value or in words as follows:

	pH		*pH*
Extremely acid	below 4.5	Mildy alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff. Surface drainage of rain or melted snow.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles of a soil that range from 0.002 millimeter (0.000079 inch) to 0.05 millimeter (0.02 inch) in diameter. The term silt is also applied to a soil that contains 80 percent or more of silt and less than 12 percent of clay.

Slope. The incline of the surface of a soil. It is generally expressed in percentage, which equals the number of feet of fall per 100 feet of horizontal distance. A slope of 3 percent, for example, is a drop of 3 feet in 100 feet of horizontal distance.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy, prismatic, columnar, blocky,* and *granular.* Structureless soils are (1) single grain—each grain by itself, as in dune sand—or (2) massive—the particles adhering together without any regular cleavage, as in many claypans or hardpans.

Subgrade, engineering. The substratum, consisting of in-place material or fill material, that is prepared for highway construction; does not include stabilized base course or actual paving material.

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Subsurface layer. The layer next to the surface layer; normally, a part of the A horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches thick.

Texture, soil. The relative proportions of the various size groups of individual soil grains in a mass of soil; specifically, the proportions of sand, silt, and clay.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, and difficult to till.

GUIDE TO MAPPING UNITS, CAPABILITY UNITS, AND RANGE SITES

See table 7, p. 34, for the approximate acreage and proportionate extent of the soils, and table 1, p. 14, for the estimated average acre yields of crops. For information significant to engineering, see section beginning p. 21. Dashes indicate that the particular mapping unit was not assigned to a range site because it was not suited to range]

Map symbol	Soil name	Page	Capability unit: Symbol	Capability unit: Page	Range site: Name	Range site: Page
Ad	Alluvial land	34	Vw-1	12	----------	15
BaB	Bates loam, 1 to 3 percent slopes	35	IIe-2	10	Loamy Prairie	15
BaC	Bates loam, 3 to 5 percent slopes	35	IIIe-1	10	Loamy Prairie	15
BaC2	Bates loam, 2 to 5 percent slopes, eroded	35	IIIe-3	11	Loamy Prairie	15
Bb	Bates loam, shallow	35	IVe-3	12	Loamy Prairie	16
BcB	Baxter silt loam, 1 to 3 percent slopes	36	IIe-2	10	Smooth Chert Savannah	16
BcC	Baxter silt loam, 3 to 5 percent slopes	36	IIIe-1	10	Smooth Chert Savannah	16
BdB	Bodine cherty silt loam, 0 to 3 percent slopes	36	IVs-1	12	Smooth Chert Savannah	16
BnD	Bodine very cherty silt loam, 1 to 8 percent slopes	36	IVs-1	12	Smooth Chert Savannah	16
BoE	Bodine stony silt loam, steep	37	VIIs-1	12	Steep Chert Savannah	15
Br	Breaks-Alluvial land complex	37	VIe-1	12	Loamy Prairie	15
ChA	Choteau silt loam, 0 to 1 percent slopes	37	I-2	9	Loamy Prairie	15
ChB	Choteau silt loam, 1 to 3 percent slopes	37	IIe-2	10	Loamy Prairie	15
Co	Collinsville soils	37	VIIs-2	13	Shallow Prairie	15
CrB	Craig silt loam, 1 to 3 percent slopes	38	IIe-2	10	Loamy Prairie	15
CrC	Craig silt loam, 3 to 5 percent slopes	38	IIIe-1	10	Loamy Prairie	15
DnA	Dennis silt loam, 0 to 1 percent slopes	38	I-2	9	Loamy Prairie	15
DnB	Dennis silt loam, 1 to 3 percent slopes	38	IIe-2	10	Loamy Prairie	15
DnC	Dennis silt loam, 3 to 5 percent slopes	38	IIIe-1	10	Loamy Prairie	15
DnC2	Dennis silt loam, 2 to 5 percent slopes, eroded	39	IIIe-3	11	Loamy Prairie	15
Ed	Eldorado soils	39	VIs-1	12	Loamy Prairie	16
EhD	Etowah gravelly silt loam, 3 to 8 percent slopes	39	IVe-2	12	Smooth Chert Savannah	16
EtA	Etowah silt loam, 0 to 3 percent slopes	39	IIe-2	10	Smooth Chert Savannah	16
Hg	Huntington gravelly silt loam	40	IIw-1	10	----------	
Hu	Huntington silt loam	40	I-1	9	----------	
Ka	Kaw silty clay loam	41	I-1	9	Loamy Bottomland	16
La	Lawrence silt loam	41	IIs-1	10	----------	
Ln	Lightning silt loam	41	IIIw-1	11	Heavy Bottomland	16
Mp	Mine pits and dumps	41	VIIIs-1	13	----------	
NaB	Newtonia silt loam, 1 to 3 percent slopes	42	IIe-2	10	Loamy Prairie	15
NaC	Newtonia silt loam, 3 to 5 percent slopes	42	IIIe-1	10	Loamy Prairie	15
NaC2	Newtonia silt loam, 2 to 5 percent slopes, eroded	42	IIIe-3	11	Loamy Prairie	15
Ns	Newtonia-Sogn complex	42	VIs-1	12	Loamy Prairie and Very Shallow	15
Os	Osage silty clay	43	IIIw-1	11	Heavy Bottomland	16
PaA	Parsons silt loam, 0 to 1 percent slopes	43	IIs-1	10	Claypan Prairie	15
PaB	Parsons silt loam, 1 to 3 percent slopes	43	IIIe-2	11	Claypan Prairie	15
PaB2	Parsons silt loam, 1 to 3 percent slopes, eroded	43	IVe-1	11	Claypan Prairie	15
RvC	Riverton gravelly loam, 3 to 5 percent slopes	44	IIIe-1	10	Loamy Prairie	15
SuB	Summit silty clay loam, 1 to 3 percent slopes	44	IIe-1	9	Loamy Prairie	15
TaA	Taloka silt loam, 0 to 1 percent slopes	45	IIs-1	10	Loamy Prairie	15
Vd	Verdigris silt loam	45	I-1	9	Loamy Bottomland	16
WoA	Woodson silty clay loam, 0 to 1 percent slopes	45	IIs-1	10	Claypan Prairie	15
WoB	Woodson silty clay loam, 1 to 3 percent slopes	45	IIIe-2	11	Claypan Prairie	15

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All Other Inquiries

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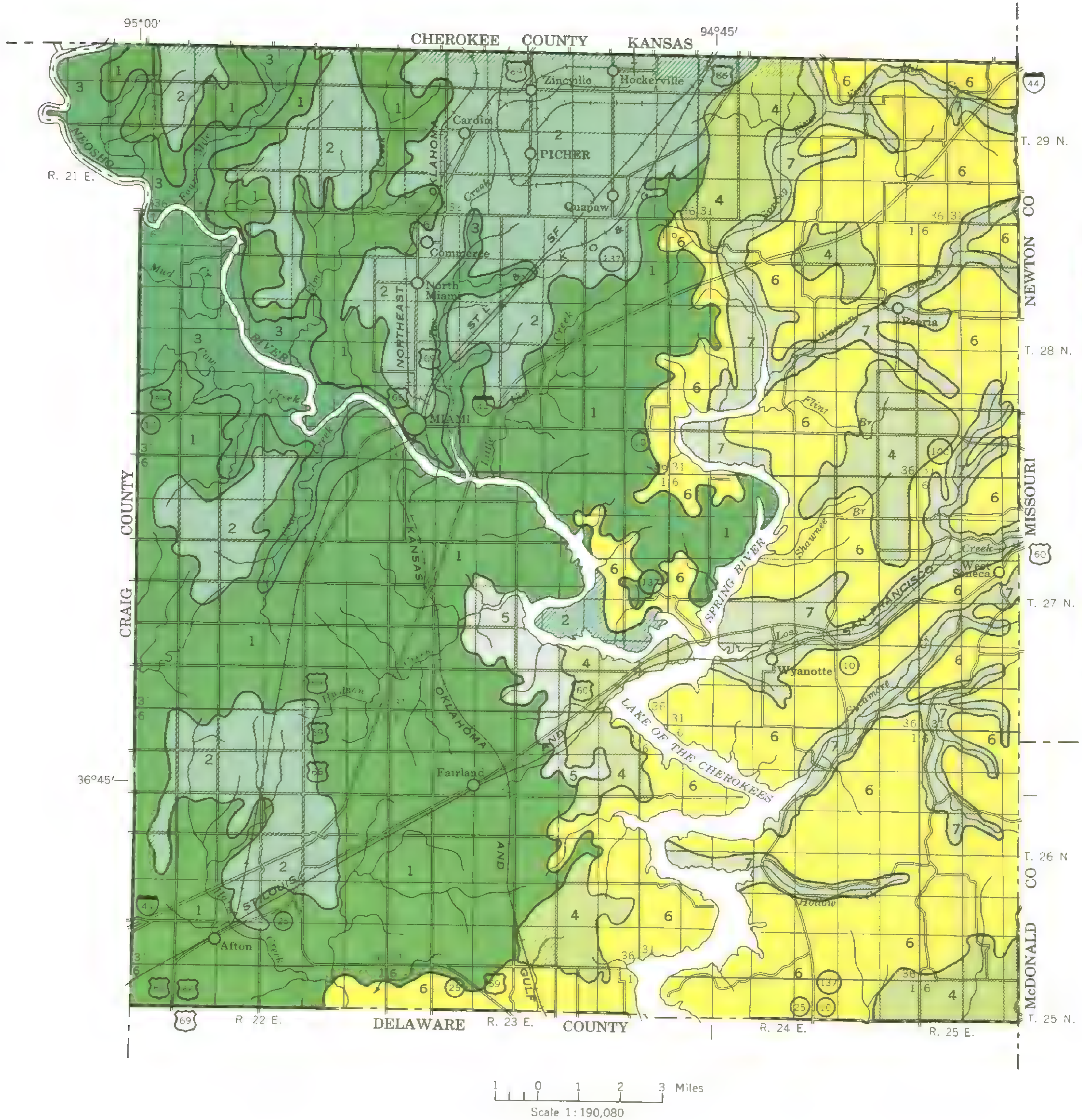


U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
OTTAWA COUNTY, OKLAHOMA

CHEROKEE PRAIRIES

1 Dennis-Parsons-Bates association: Nearly level to moderately sloping upland soils formed in material from sandstone and shale

2 Dennis-Taloka association: Nearly level to moderately sloping upland soils formed in material from sandstone and shale or in old alluvium

3 Osage-Verdigris-Lightning association: Nearly level soils on flood plains

4 Craig-Eldorado association: Moderately deep and shallow upland soils formed in material from cherty limestone

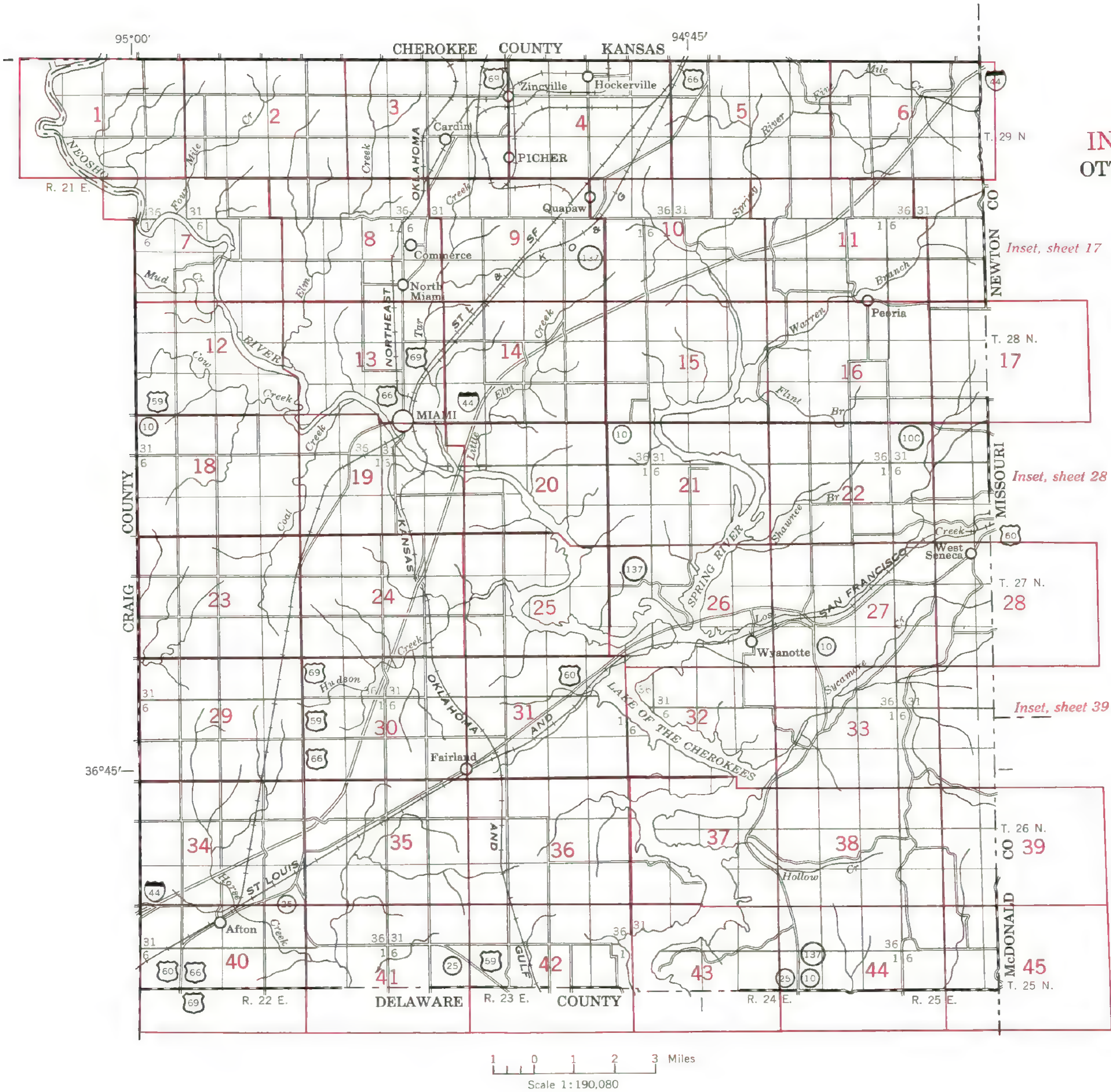
5 Newtonia-Summit association: Gently sloping to moderately sloping upland soils formed in material from limestone and shale

OZARK HIGHLANDS

6 Bodine-Baxter association: Nearly level to steep upland soils formed in material from cherty limestone

7 Huntington-Etowah association: Nearly level to moderately sloping gravelly soils formed in alluvium on flood plains and benches

INDEX TO MAP SHEETS
OTTAWA COUNTY, OKLAHOMA



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, if used, shows the slope. Some symbols that do not contain a slope letter are for nearly level soils such as Huntington silt loam, but others are for soils that have a considerable range of slope, such as the Eldorado soils. A final number, 2, in the symbol shows that the soil is eroded.

SYMBOL	NAME
Ad	Alluvial land
BaB	Bates loam, 1 to 3 percent slopes
BaC	Bates loam, 3 to 5 percent slopes
BaC2	Bates loam, 2 to 5 percent slopes, eroded
Bb	Bates loam, shallow
BcB	Baxter silt loam, 1 to 3 percent slopes
BcC	Baxter silt loam, 3 to 5 percent slopes
BdB	Bodine cherty silt loam, 0 to 3 percent slopes
BnD	Bodine very cherty silt loam, 1 to 8 percent slopes
BoE	Bodine stony silt loam, steep
Br	Breaks-Alluvial land complex
ChA	Choteau silt loam, 0 to 1 percent slopes
ChB	Choteau silt loam, 1 to 3 percent slopes
Co	Collinsville soils
CrB	Craig silt loam, 1 to 3 percent slopes
CrC	Craig silt loam, 3 to 5 percent slopes
DnA	Dennis silt loam, 0 to 1 percent slopes
DnB	Dennis silt loam, 1 to 3 percent slopes
DnC	Dennis silt loam, 3 to 5 percent slopes
DnC2	Dennis silt loam, 2 to 5 percent slopes, eroded
Ed	Eldorado soils
EhD	Etowah gravelly silt loam, 3 to 8 percent slopes
EtA	Etowah silt loam, 0 to 3 percent slopes
Hg	Huntington gravelly silt loam
Hu	Huntington silt loam
Ka	Kaw silty clay loam
La	Lawrence silt loam
Ln	Lightning silt loam
Mp	Mine pits and dumps
NaB	Newtonia silt loam, 1 to 3 percent slopes
NaC	Newtonia silt loam, 3 to 5 percent slopes
NaC2	Newtonia silt loam, 2 to 5 percent slopes, eroded
Ns	Newtonia-Sogn complex
Os	Osage silty clay
PaA	Parsons silt loam, 0 to 1 percent slopes
PaB	Parsons silt loam, 1 to 3 percent slopes
PaB2	Parsons silt loam, 1 to 3 percent slopes, eroded
RvC	Riverton gravelly loam, 3 to 5 percent slopes
SuB	Summit silty clay loam, 1 to 3 percent slopes
TaA	Taloka silt loam, 0 to 1 percent slopes
Vd	Verdigris silt loam
WoA	Woodson silty clay loam, 0 to 1 percent slopes
WoB	Woodson silty clay loam, 1 to 3 percent slopes

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferries
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries

Borrow pit — B. P.

Pits, gravel

Power lines

Pipe lines

Cemeteries

Dams

Levees

Tanks

Oil wells

Windmills

BOUNDARIES

- National or state
- County
- Township, U. S.
- Section line, corner
- Reservation
- Land grant

DRAINAGE

Streams
- Perennial
- Intermittent, unclass.

Canals and ditches — CANAL, DITCH

Lakes and ponds
- Perennial
- Intermittent

Wells — flowing

Springs

Marsh

Wet spot

RELIEF

Escarpments
- Bedrock
- Other

Prominent peaks

Depressions — Large, Small
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stones, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gullies

Soil map constructed 1963 by Cartographic Division, Soil Conservation Service, USDA, from 1958 aerial photographs. Controlled mosaic based on Oklahoma plane coordinate system, north zone, Lambert conformal conic projection. 1927 North American datum.

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 1

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Range, township, and section corners shown on this map are indefinite.

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 2

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 3

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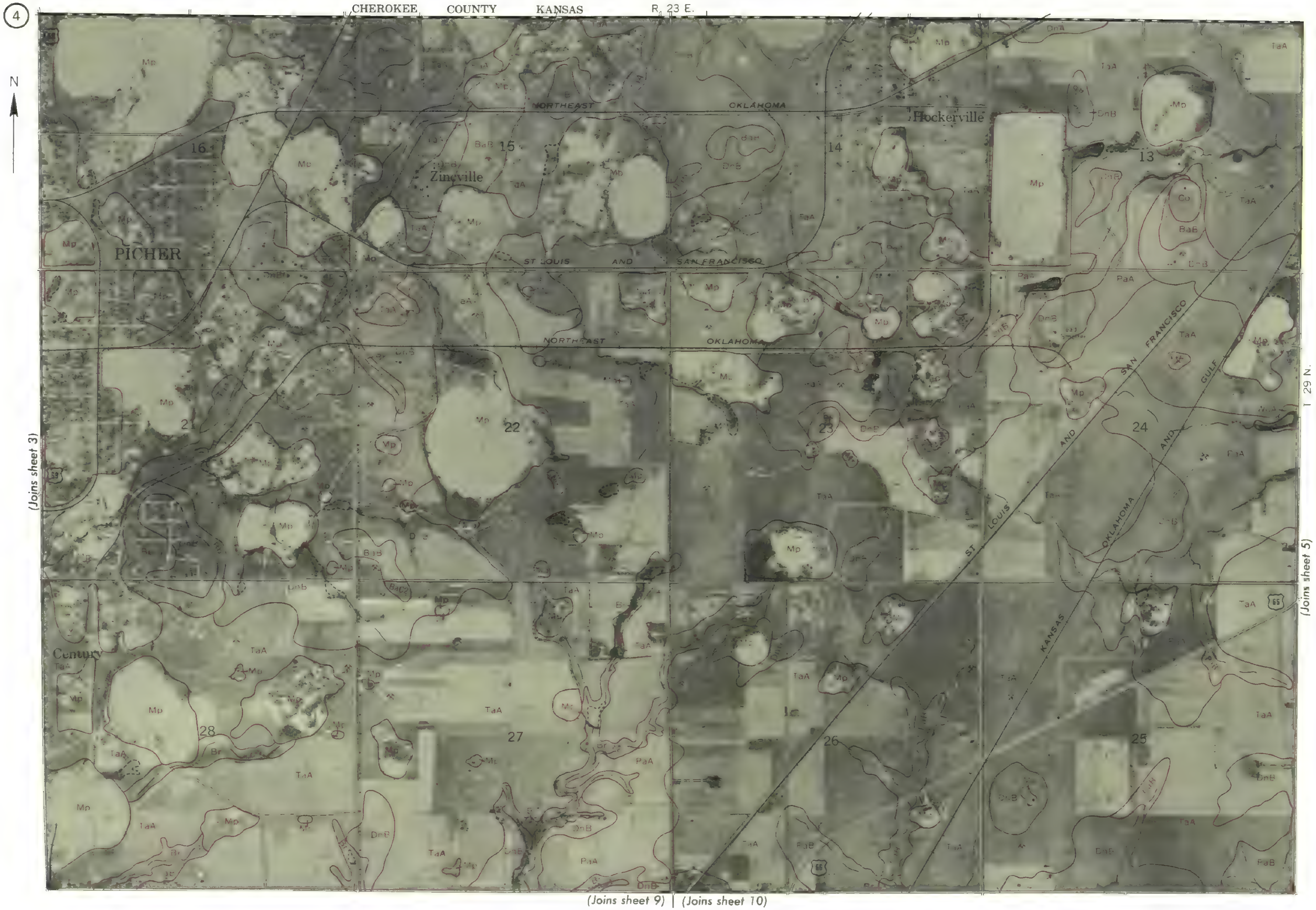
0 ½ 1 Mile Scale 1:20 000 0 5000 Feet



0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 6

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is compiled ... as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture and the Oklahoma Agricultural Experiment Station

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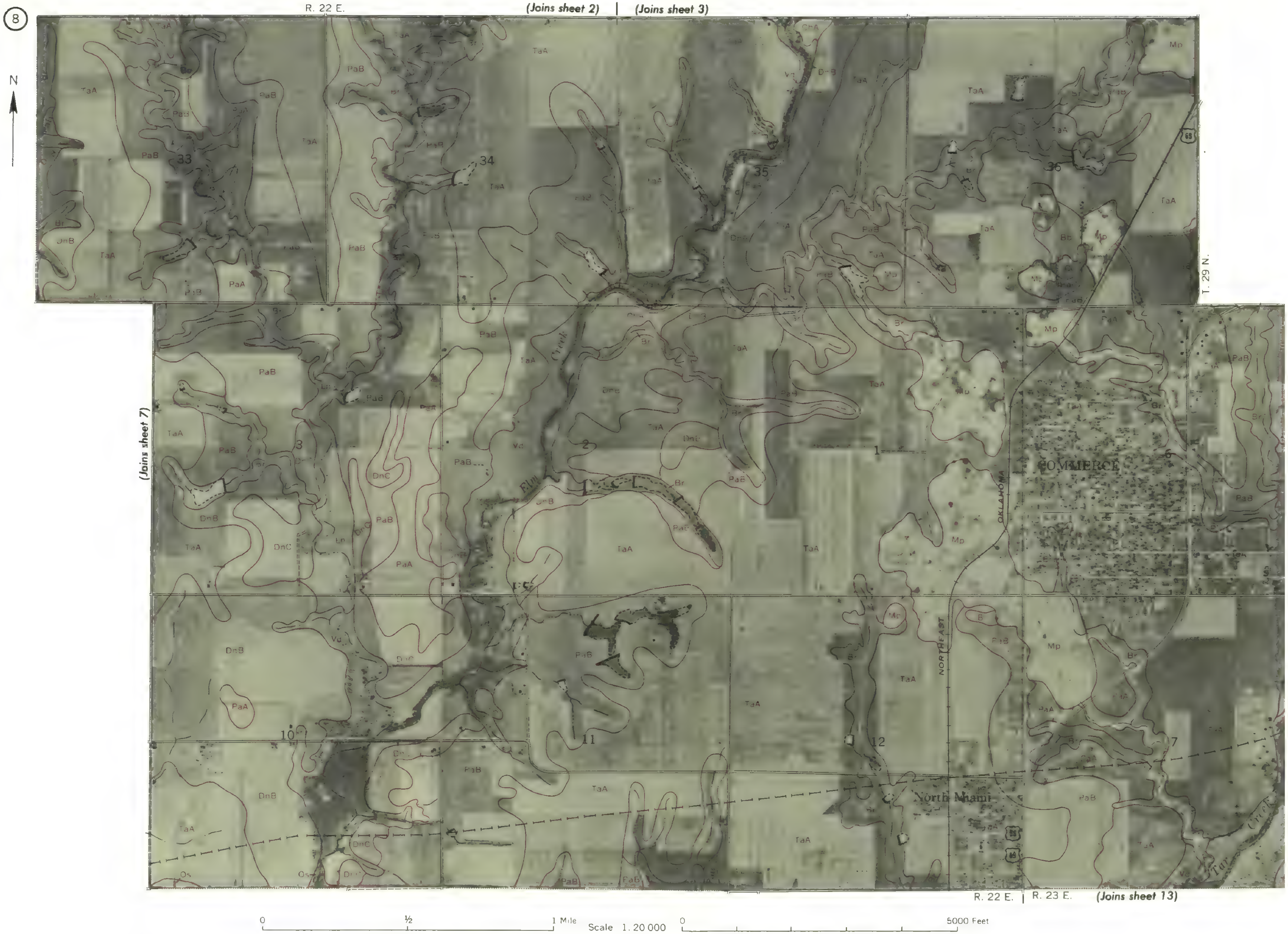
8
R. 22 E.
(Joins sheet 2)
(Joins sheet 3)
N
(Joins sheet 7)
T. 29 N.
COMMERCE
North Miami
NORTHEAST
OKLAHOMA
Elm Creek
Tar Creek
R. 22 E.
R. 23 E.
(Joins sheet 13)
0
½
1 Mile
Scale 1:20 000
0
5000 Feet

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 9

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Range, township, and section corners shown on this map are indefinite.


10
(Joins sheet 4)
R. 23 E. | R. 24 E.
(Joins sheet 5)
N
Quapaw
35
36
31
32
T. 29 N.
SPRING
RIVER
Spring River Church
1
6
5
4
12
7
8
9
(Joins sheet 9)
(Joins sheet 15)
R. 23 E. | R. 24 E.
BORROW PIT
0
½
1 Mile
Scale 1:20 000
0
5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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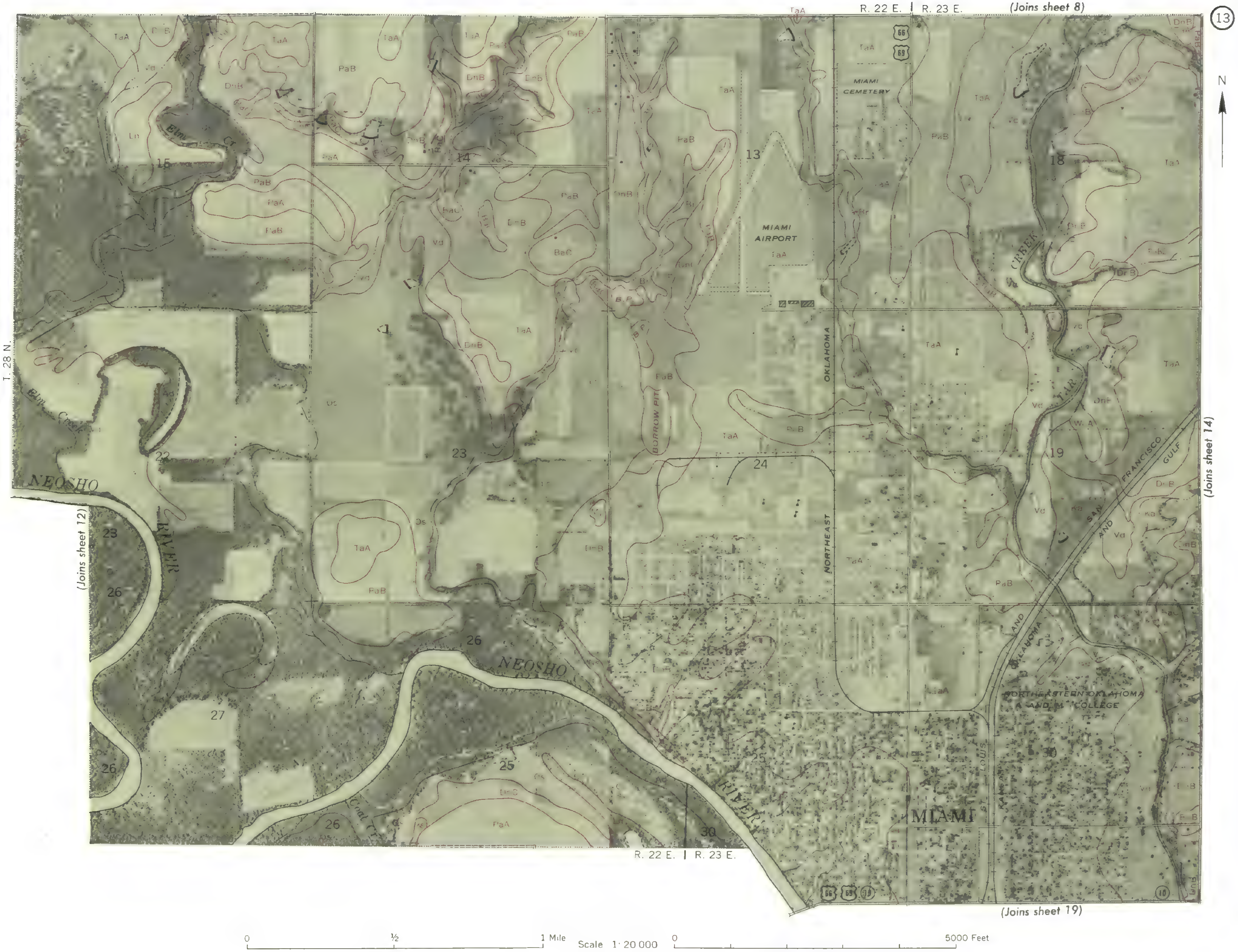
Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



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Range, township, and section corners shown on this map are indefinite

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 14

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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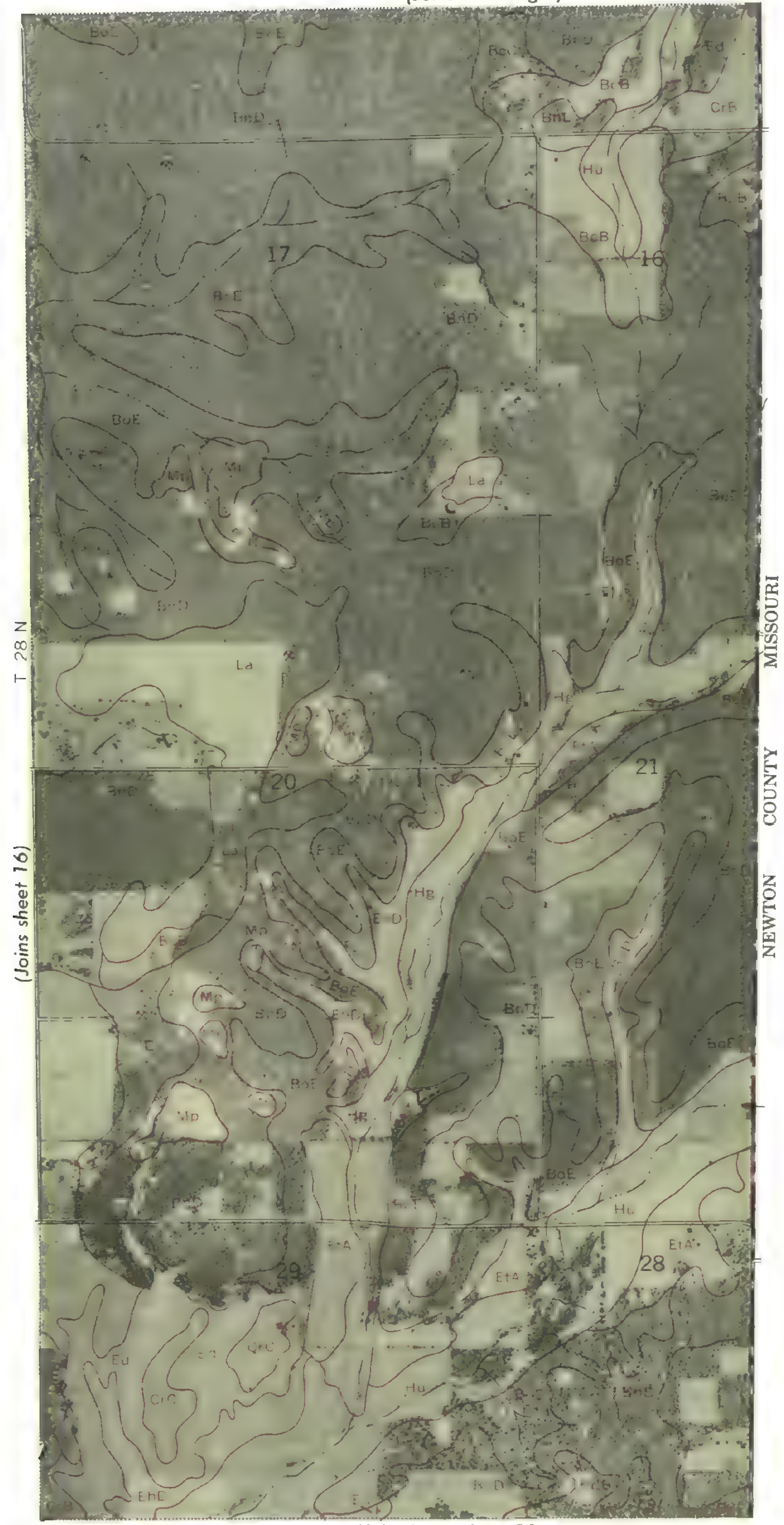
Range, township, and section corners shown on this map are indefinite.


16
(Joins sheet 11)
N
R. 24 E.
R. 25 E.
T. 28 N.
(Joins sheet 15)
(Joins sheet 17)
(Joins sheet 22)
Warren
Branch
Flint
Branch
GRAVEL
13
14
15
18
19
22
23
24
25
26
27
30
BdB
BnD
BcB
EtA
Hg
HaA
CrB
DnB
DhA
TaA
La
0
½
1 Mile
Scale 1:20 000
0
5000 Feet

17

R. 25 E.

(Joins lower right)



(Joins inset, sheet 28)

(Joins sheet 6)

(Joins upper left)

N

Scale 1:20 000

0 ½ 1 Mile

0 5000 Feet

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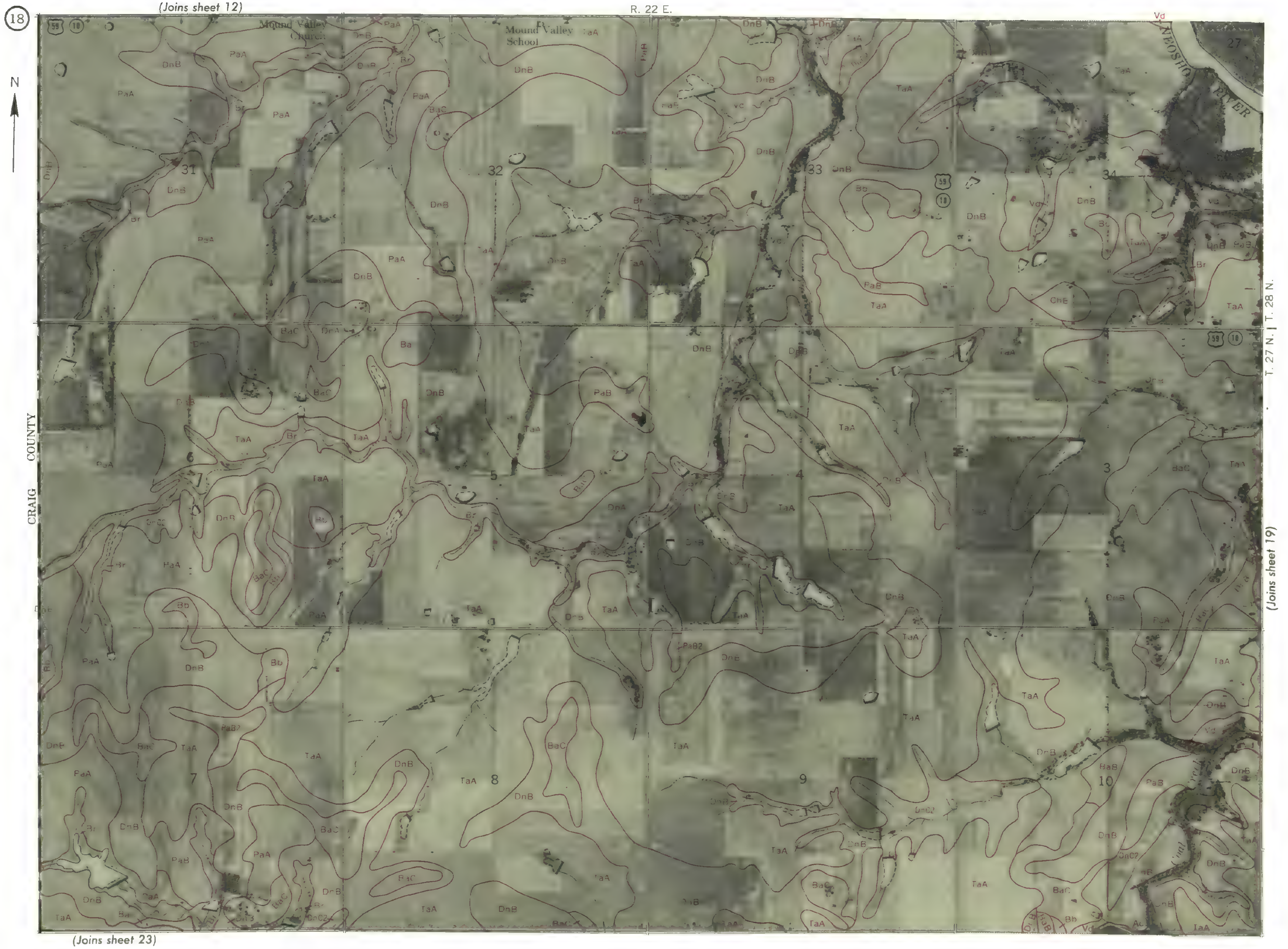
OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 18



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

19

N

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 20

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

R. 24 E. | R. 23 E.

(Joins sheet 15)

21

N

T. 28 N. | T. 27 N.

(Joins sheet 20)

(Joins sheet 22)

(Joins sheet 26)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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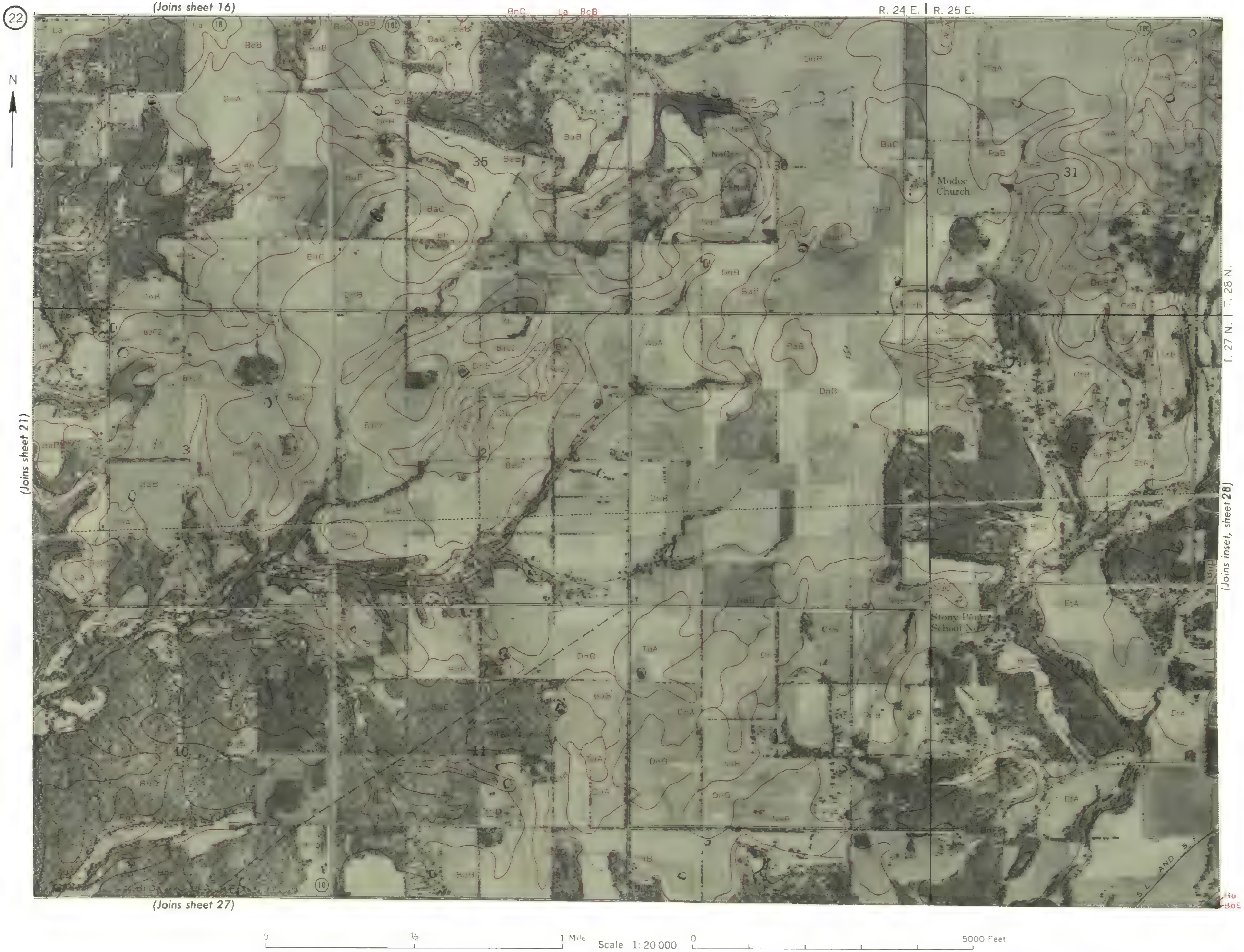
Range, township, and section corners shown on this map are indefinite.


22
(Joins sheet 16)
R. 24 E. | R. 25 E.
N
(Joins sheet 21)
T. 28 N. | T. 27 N.
(Joins inset, sheet 28)
(Joins sheet 27)
Modoc Church
34
35
36
31
3
2
6
10
11
0
½
1 Mile
Scale 1:20 000
0
5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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Range, township, and section corners shown on this map are indefinite

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 24

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

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Range, township, and section corners shown on this map are indefinite

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


26
(Joins sheet 21)
R. 23 E. R. 24 E.
N
(Joins sheet 25)
(Joins sheet 27)
T. 27 N.
R. 23 E.
(Joins sheet 31)
R. 24 E.
(Joins sheet 32)
Longs Church
ROADSIDE PARK
BORROW PIT
LAKE OF THE CHEROKEES
SENECA INDIAN SCHOOL
LOST CREEK
Wyandotte
Moreville
ST LOUIS AND SAN FRANCISCO
0 ½ 1 Mile
Scale 1:20 000
0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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Range, township, and section corners shown on this map are indefinite

(28)

(Joins lower right)

R. 25 E.

(Joins sheet 27)

T. 27 N.

MISSOURI

NEWTON COUNTY

(Joins sheet 39)

(Joins sheet 17)

(Joins sheet 22)

T. 28 N. | T. 27 N.

MISSOURI

COUNTY

NEWTON

(Joins upper left)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 30

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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Range, township, and section corners shown on this map are indefinite.

32

(Joins sheet 26)

(Joins sheet 31)

(Joins sheet 33)

(Joins sheet 37) BoE

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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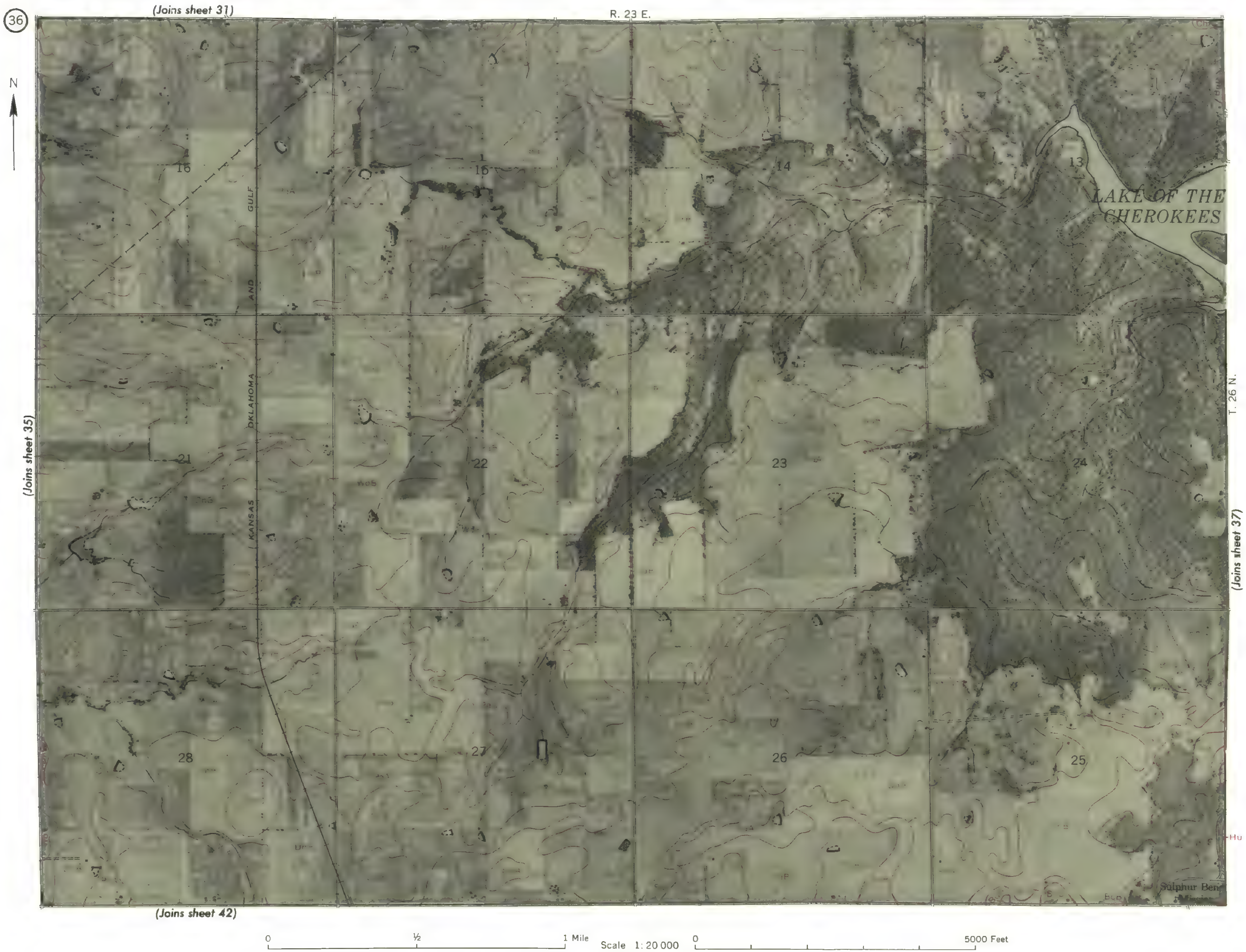
Range, township, and section corners shown on this map are indefinite.


34
(Joins sheet 29)
R. 22 E.
N
18
17
16
15
19
20
21
22
30
29
28
27
CRAIG COUNTY
T. 26 N.
(Joins sheet 35)
(Joins sheet 40)
SAN FRANCISCO
AND
ST. LOUIS
HORSE CREEK
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Range, township, and section corners shown on this map are indefinite.


36
(Joins sheet 31)
R. 23 E.
N
16
15
14
13
LAKE OF THE
CHEROKEES
GULF
AND
OKLAHOMA
KANSAS
(Joins sheet 35)
21
22
23
24
T. 26 N.
(Joins sheet 37)
28
27
26
25
Sulphur Bend
(Joins sheet 42)
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 38

38

(Joins sheet 33)

R. 24 E. | R. 25 E.

N

(Joins sheet 37)

T. 26 N.

(Joins sheet 39)

(Joins sheet 44)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Range, township, and section corners shown on this map are indefinite

R. 25 E

39

(Joins lower right)

(Joins sheet 38)

T. 26 N.

(Joins sheet 45)

(Joins sheet 28)

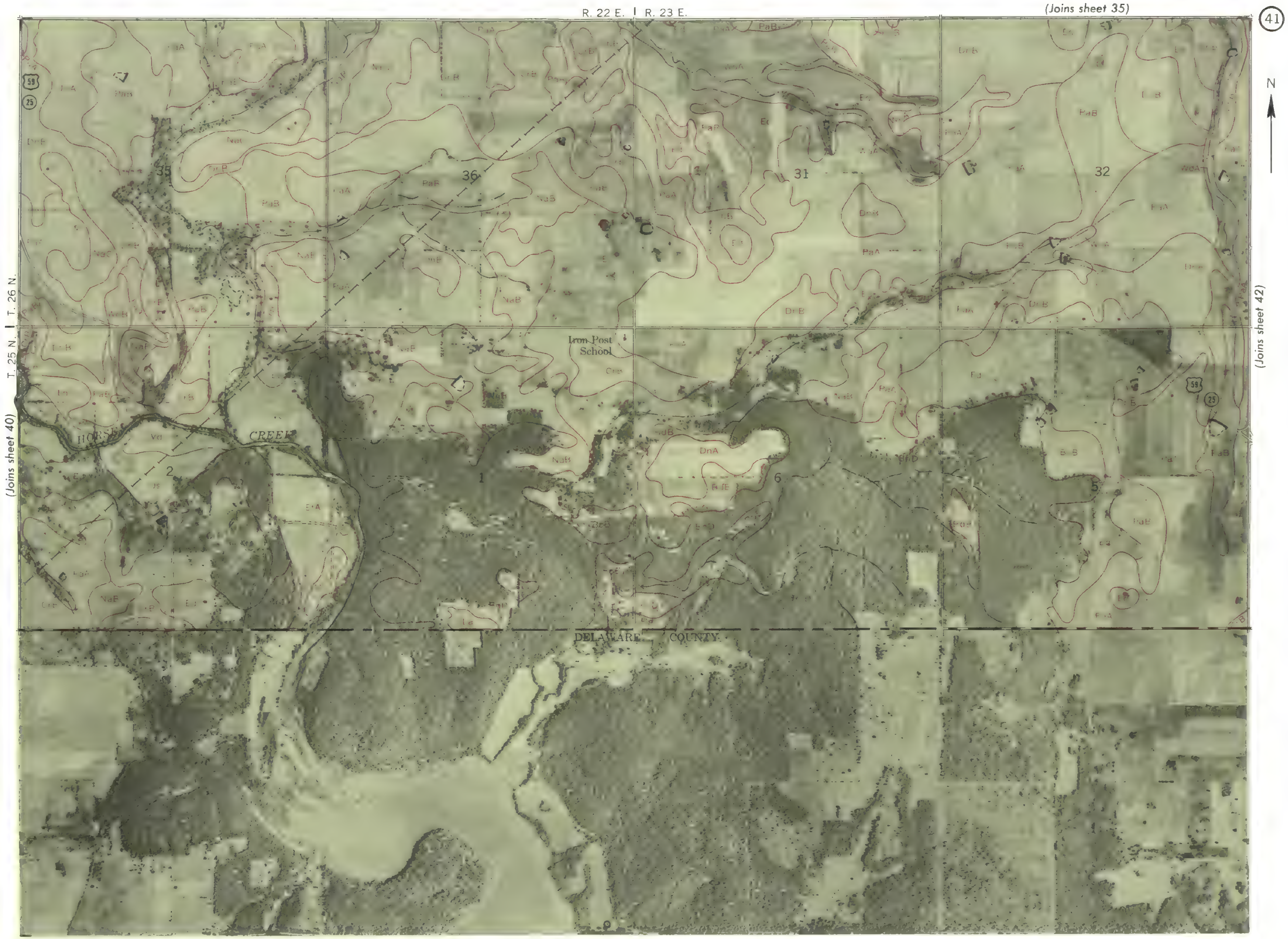
(Joins sheet 33)

T. 27 N.
T. 26 N.

(Joins upper left)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet



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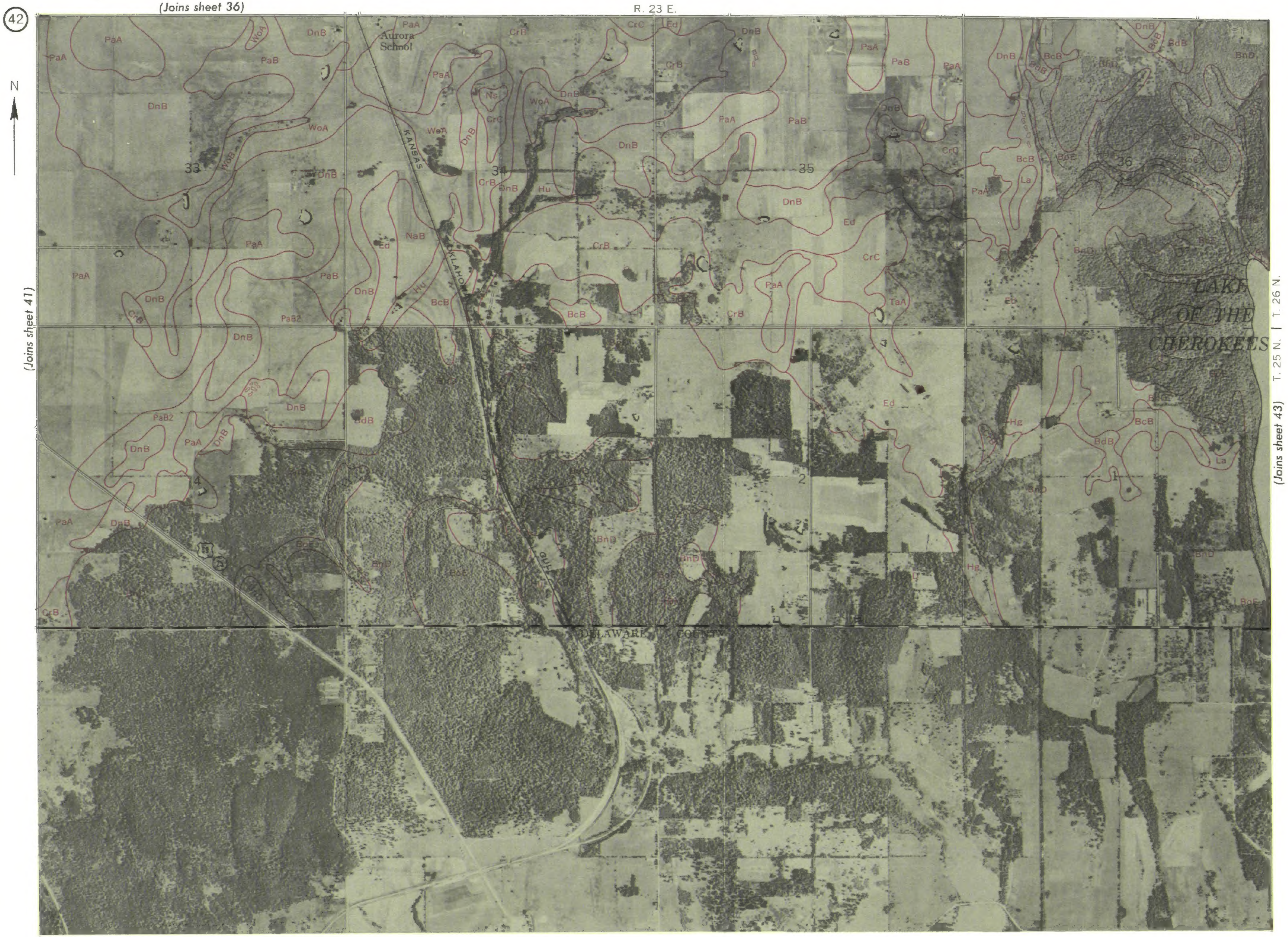
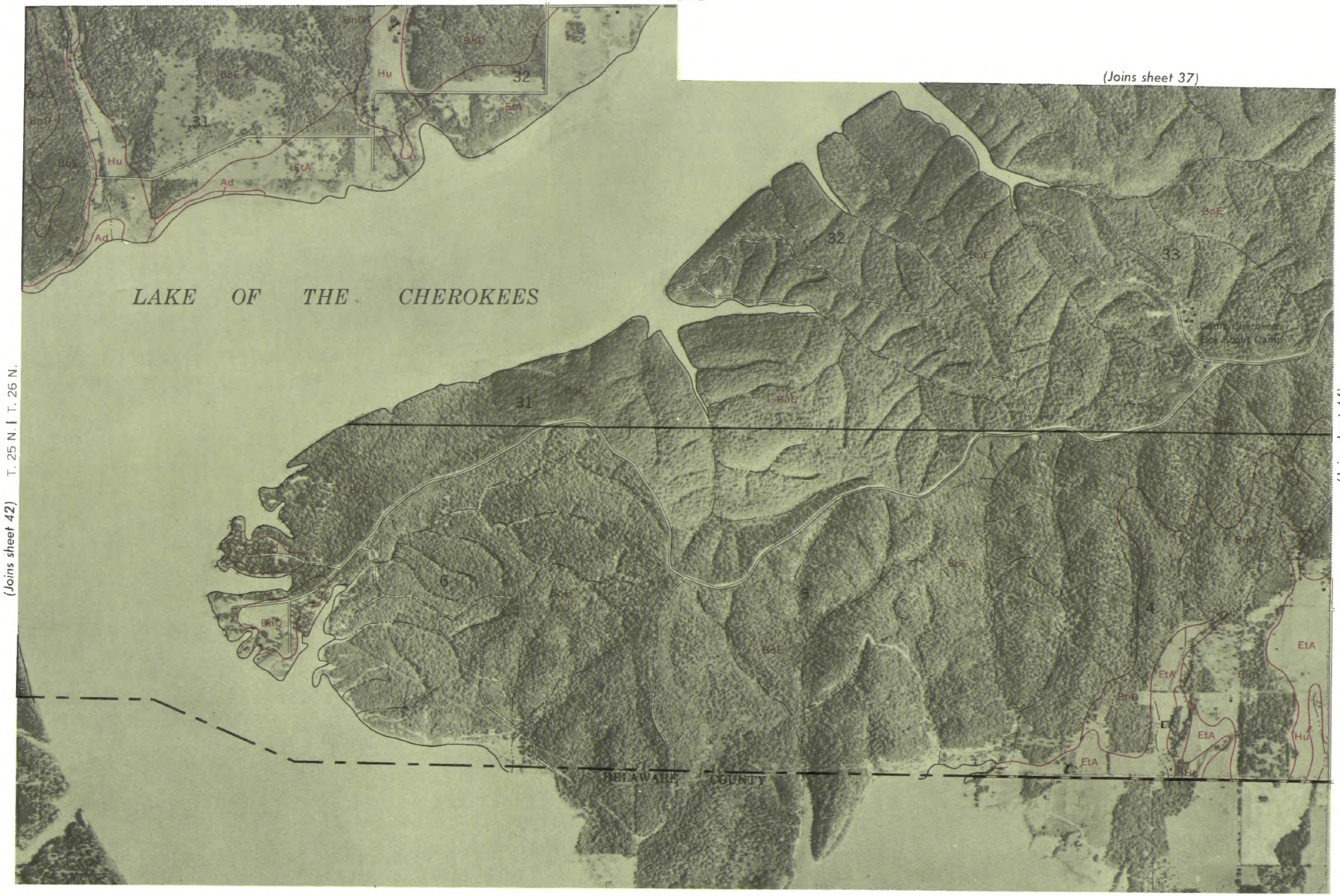
0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 42



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

OTTAWA COUNTY, OKLAHOMA — SHEET NUMBER 44

(44)

(Joins sheet 38)

R. 24 E. | R. 25 E.

N

(Joins sheet 43)

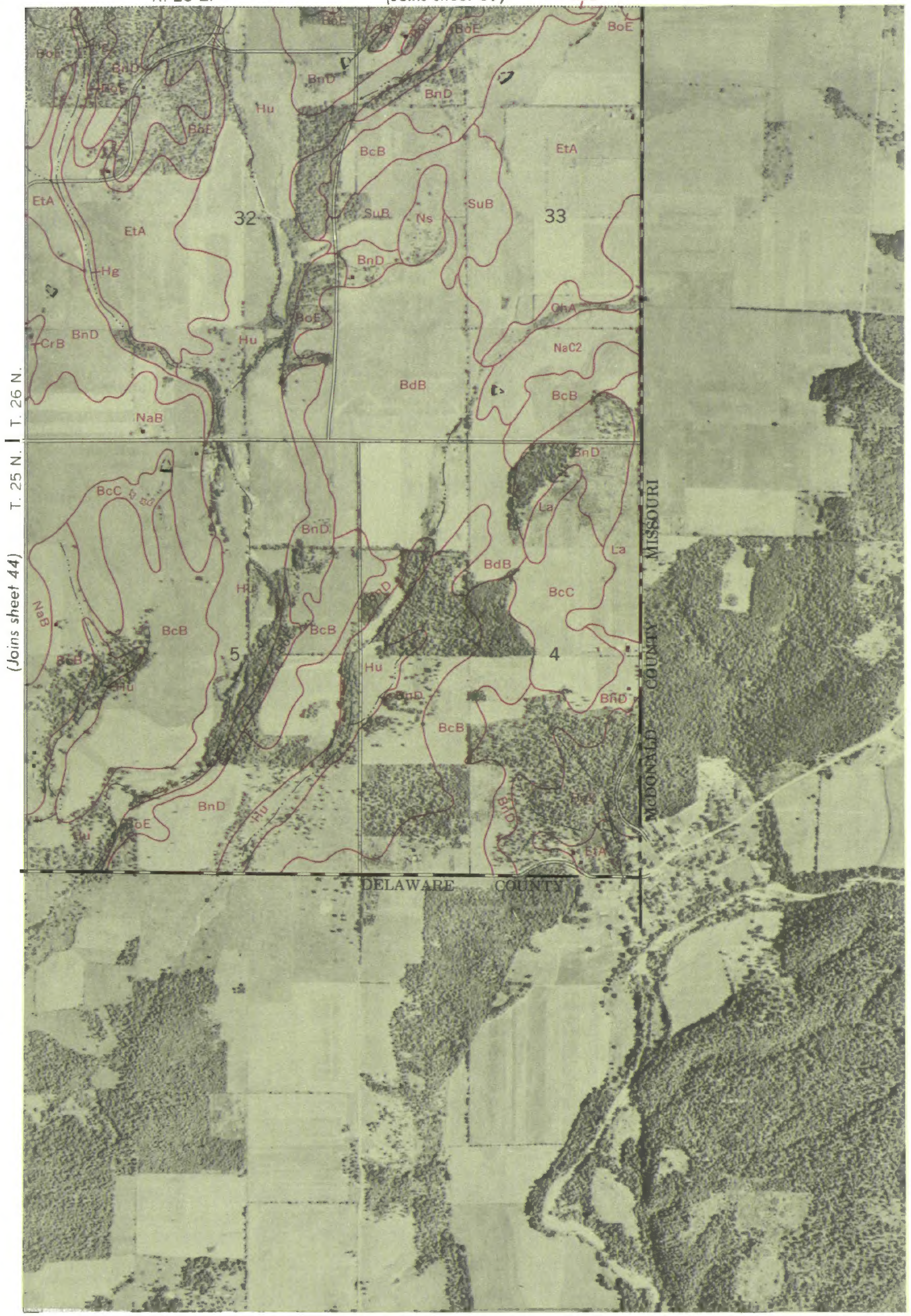
T. 26 N. | T. 25 N.

(Joins sheet 45)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

45

R. 25 E. (Joins sheet 39)



T. 26 N. T. 25 N.

(Joins sheet 44)

N

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1963 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Range, township, and section corners shown on this map are indefinite